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MANAGEMENT CONCEPTS FOR SMALL-SCALE FISHERIES: ECONOMIC AND SOCIAL ASPECTS

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

MANAGEMENT CONCEPTS FOR SMALL-SCALE FISHERIES: ECONOMIC AND SOCIAL ASPECTS

by

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PREPARATION OF THIS PAPER

This document has been prepared as part of FAO's Regular Programme activities, aimed at assisting fishery administrators and other persons responsible for the management of fisheries. It is the fifth in a series of technical papers relating to the PRACTICES OF FISHERIES MANAGEMENT.

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ABSTRACT

This paper provides an analytical framework for the management and development of coastal small-scale fisheries in developing countries. In a brief review the basic management concepts developed for single-species fisheries are presented and their appropriateness is examined for the management and development of small-scale multi-species fisheries. Apart from the higher biological complexity of multi-species fisheries the traditional management concepts also need refinement for socio-economic reasons. The paper describes the constraints under which many small-scale fishermen operate, viz., resource limitation, conflicts with large-scale fisheries, lack of geographical and occupational mobility and lack of alternative employment opportunities. These constraints may temporarily call for higher levels of fishing effort than justifiable from a pure economic efficiency point of view. Still, any long-term improvements in the living standard of small-scale fishermen will necessitate some forms of human intervention, which allocate the resource between different sections of the fishing industry and in general limit the expansion of fishing effort to prevent wastage of capital and human resources. The paper discusses various measures to regulate fishing effort in small-scale fisheries, viz., selectivity of gear; seasonal and area closures; catch quotas; limits on the number of fishing units, on the quantity of gear, or on the catching capacity of vessels; economic controls such as taxes, royalties or licence fees; and resource allocation through territorial rights. The choice among these management alternatives should be based on a set of criteria which include: acceptance by the fishermen, gradual implementation, flexibility, encouragement of efficiency and innovation, full cognizance of regulation and enforcement costs, and due attention to employment and distributional implications. Owing to the geographically dispersed nature of artisanal fisherfolk settlements, the revival and rejuvenation of traditional territorial community rights over coastal resources offer perhaps the best possible management option for small-scale fisheries. Instead of attempting to control fishing directly, such rights aim at creating a conducive environment of self-control by the fishermen themselves. The paper concludes with a presentation of some examples of traditional territorial fishing rights in Brazil, Japan, Sri Lanka and Ivory Coast.

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1. INTRODUCTION

The marine fisheries world-wide are characterized by a dualism in the form of coexistence of small-scale or artisanal fisheries side-by-side with large-scale or industrial fisheries. 1/ The dualism is not confined to the scale of operation but extends to the type of technology used, the degree of capital intensity, employment generation and ownership. In contrast to large-scale fisheries, artisanal fisheries are owner-operated and labour-intensive using little capital and hardly any modern technology.

Past development efforts have focussed almost exclusively on large-scale fisheries presumably in the belief that small-scale fisheries were only a temporary feature of the transition from artisanal to industrial fisheries. It was presumed that small-scale fishermen would either acquire the new technology and join the race for offshore and distant-water resource or they would find employment as crewmen in the large-scale fisheries. Alternatively, they could move to more lucrative occupations inland which presumably would have been generated by rapid economic growth.

However, after more than three decades of fisheries development, it is estimated that there are still about 10 million small-scale fishermen landing around 20 million tons of fish annually, which accounts for almost half the world marine catch used for direct human consumption (Thomson, 1980). Yet, with the exception of some motorization of canoes and the introduction of nylon nets, the fishing technology of small-scale fishermen in many parts of the world remained largely unchanged for decades. This, however, may have been a blessing in disguise for the economies of many developing countries which suffer from severe scarcity of capital and foreign exchange, ever-rising fuel-import bills and chronic underemployment. It has been estimated that the small-scale fishery uses one-fifth as much capital and one-fourth to one-fifth as much fuel per ton of fish landed and creates a hundred times more jobs per dollar invested than the large-scale fishery (Thomson, 1980). Yet in many developing countries, small-scale fishermen live close to or below the subsistence level or at any rate they are among the lowest socio-economic groups in the country (Smith, 1979; Panayotou, 1980; Panayotou et al., in press; Fredericks et al., in press; Librero et al., in press; and others).

Thus, the fundamental problem of small-scale fishermen around the developing world is their persisting absolute and relative poverty 2/ despite decades of remarkable overall fisheries development and national economic growth. Clearly, they have neither adopted the advanced fishing technology nor did they find employment in the large-scale fishery or elsewhere as it was presumed, for reasons ranging from capital market distortions and the (consequent) capital intensity of the large-scale fishery to the limited mobility of the small-scale fishermen or the lack of alternative employment. Thus, there is a need to put small-scale fisheries in the right perspective and examine the available policy options for improving their socio-economic condition and maximizing their overall contribution to national economic and social development.

1/ There is no standard definition of small-scale fisheries. There exist various classifications into small-scale and large-scale, into artisanal and commercial and into inshore and offshore according to vessel size (Indonesia, Philippines), gear type (Thailand), distance from shore (Hong Kong, Singapore) or a combination of the three (Malaysia). Thus, it is not unusual to find what is considered a small-scale fishery in one country to be classified as a large-scale fishery in another. As Smith (1979) pointed out such narrow definitions, though useful at the national level "are not so useful when attempting to gain a broad understanding of the traditional fisheries sector. Rather than attempting to be specific, therefore, one could more usefully talk about ranges or rough categorizations of the technical and socio-economic characteristics of the fishing activities of fishermen". Our rough categorization in the present study is between those who have a broad spectrum of options both in terms of fishing grounds and non-fishing investment opportunities (large-scale fishermen) and those who, by virtue of their limited fishing range and a host of related socio-economic characteristics, are confined to a narrow strip of land and sea around their community, faced with a limited set of options, if any, and intrinsically dependent on the local resources (small-scale fishermen). It is in this context that the dualism in post-war fisheries development should be understood and tackled, despite the existence of few (or even many) intermediate cases.

2/ The relative poverty of small-scale fishermen has been defined and measured not only by comparison to the national average level of income but also, and more significantly, in relation to incomes and amenities of similar socio-economic groups, e.g. farmers, other rural dwellers and urban workers (see studies in Panayotou, et al., in press).

The socio-economic problems of small-scale fishermen are currently attracting increased attention due to: (a) the realization that small-scale fisheries are not a transitory feature of fisheries development; (b) increased interest in improving the socio-economic conditions of low-income groups in general; and (c) the new opportunities for local fisheries made available by the declaration of extended fisheries jurisdictions. In response, governments in developing countries are considering development assistance measures for upgrading small-scale fisheries. However, such efforts may be frustrated without a thorough understanding of the factors responsible for their currently depressed situation and the existing potential for further development. Moreover, improving the standard of living of small-scale fishermen is but one of the objectives in a fisheries policy. Other, often competing, objectives are employment creation, increase in fish supplies for domestic consumption and exports, and maximization of the economic surplus generated by the fishery.

Thus, the objectives of the present study are: (a) to identify the constraints under which small-scale fisheries operate, i.e. the factors which have constrained income levels in the past and should be considered in any future development plans; (b) to analyze the likely effects of alternative management regulations and development programmes in the light of these constraints and of the new opportunities; (c) to review possible strategies for managing and developing small-scale fisheries in the broader context of overall national fishery management and rural development.

To address these issues, an analytical framework incorporating and integrating the biological, economic and social aspects of the small-scale fishery and its interface with other sectors of the national economy is necessary. For this purpose, we begin by briefly reviewing the basic concepts of fishery management. Having realized the lack of an appropriate analytical tool for the study of small-scale multispecies fisheries we proceed to develop a bio-socio-economic model which forms the conceptual framework for the remainder of the study.

2. BRIEF REVIEW OF THE BASIC CONCEPTS OF FISHERY MANAGEMENT

Fishery management is the pursuit of certain objectives through the direct or indirect control of effective fishing effort or some of its components 3/. For example, a minimum mesh size may be instituted and enforced for the purpose of regulating the size of fish at fish capture and increasing the productivity of the resource; or, a system of licences may be introduced in order to control entry into the fishery for the purpose of maximizing the economic returns from the fishery. Fishery development, on the other hand, is the expansion of effective effort through a set of assistance programmes again for the purpose of attaining certain objectives. For example, the fishing range of canoes may be expanded through subsidized motorization for the purpose of exploiting underutilized resources and increasing fish supplies and fishermen's incomes. Fishery development may be defined more broadly to include, in addition to the expansion of fishing effort, improvement in post-harvest technology, marketing and transportation of fishery products as well as the provision of infrastructure and other related facilities. 4/

Because of its "control" feature, fishery management is thought to be required once a fishery becomes "overexploited", while fishery development is thought to apply while a fishery is still "underexploited" 5/. This need not be so. One need not wait for overfishing to occur before management measures are taken. Overfishing is better avoided by judicious management measures taken along with development. Similarly, the need for development is not confined to underexploited fisheries.

3/ The indirect control of effort includes the case in which a management authority does not get involved in the control of effort but simply creates the appropriate environment for its control by the fishermen themselves (e.g. community property rights).

4/ Of course, as we will see in section 4.3 below, any form of fishery development which makes fishing more profitable will lead (indirectly) to an expansion of effort unless it is combined with fisheries management. In the sequel we focus on fishery management and development narrowly defined, broadening our focus as we go along to include these other aspects of fishery development. Finally, in section 4.3 we focus on assistance programmes for fishery development broadly defined.

5/ The definitions of the terms "overexploitation" and "underexploitation" depend essentially on the objective being pursued for the fishery; they are loosely used here but their meaning in the sequel is clear from the context.

As management of overexploited fisheries sooner or later involves the regulation of fishing effort, development, fishery-related or otherwise, is needed to absorb the surplus labour and capital. In many developing countries, enforcement of management regulations is virtually impossible without development of sufficiently attractive employment alternatives elsewhere. Moreover, further "development" of an already "overexploited" fishery 6/ may not be as unwarranted as it sounds if the purpose is a temporary solution of otherwise intractable social problems.

These interrelations notwithstanding, the priority in overexploited fisheries is for management and in underexploited fisheries for development. Thus, the general objective of both management and development is the attainment of the "optimum" rate of exploitation of the fishery. How this optimum is defined depends, of course, on the specific objectives of the policy-makers. If the policy objective is maximum fish production then the optimum rate of exploitation is defined by the maximum sustainable yield (MSY), that is, the maximum catch that can be obtained on a sustained basis. If the actual catch is less than the MSY because of insufficient fishing effort the fishery is said to be "biologically" underexploited and further development is possible, while if the catch is less than MSY because of excess effort the fishery is "biologically" overexploited and management is called for 7/. Thus, it is not sufficient to know the MSY and to compare it with the actual catch; we need also to know the fishing effort required to obtain MSY and to compare it with actual effort.

If, on the other hand, the policy objective is to maximize the economic benefit to the national economy from the fishery, the optimum rate of exploitation is defined by the maximum economic yield (MEY), that is, the maximum sustainable surplus of revenues over fishing costs. Alternatively, MEY may be thought of as a modification of MSY to take into account the value of the fish caught and the cost of catching it. The fishery is said to be underexploited in the economic sense and to require further development if the actual catch falls short of MEY due to insufficient effort. Analogously, the fishery is said to be overexploited in the economic sense and to call for management if the actual catch falls short of MEY due to excess fishing effort.

In cases where social considerations, such as the improvement of socio-economic conditions of small-scale fishermen, generation of employment opportunities and improvement of income distribution matter, the optimum rate of exploitation is defined by a third concept, the maximum social yield (MScY) 8/. This is the level of catch and corresponding effort which provides the best possible solution to social problems given the policy objectives and all possible alternatives. Alternatively, the MScY may be thought of as modification of the MEY to account for non-purely-efficiency aspects, such as poverty and distribution. Introduction of social considerations may limit the speed with which management measures are introduced, or it may justify a more intensive rate of fishing than is justified on purely economic grounds. Thus, levels of effort below the one corresponding to MScY may be termed socio-economic underexploitation, while levels of effort above it, socio-economic overexploitation. Obviously, this latter concept, MScY, is the one most applicable to the case of small-scale fisheries in which socio-economic considerations often override both biological and strictly economic concerns.

However, estimation of MScY cannot be made independently of MSY and MEY. As biological aspects enter the economic model, which more appropriately may be termed "bio-economic", so do both biological and economic parameters enter the determination of MScY, which may be more appropriately termed a "bio-socio-economic" model. Thus, before attempting to construct such a model for determining MScY, it is necessary to review the basic biological and economic aspects of fishery management and corresponding models.

6/ "Overexploited" in the narrow sense that the catch (or profit) is less than the maximum possible due to excess fishing effort.

7/ This is not to say that MSY is a biological concept. There is nothing "biological" about it except that it corresponds to the maximum natural growth of the stock and it has been suggested by early fishery biologists as a possible objective of fishery management. MSY is, in some sense, an economic concept without, however, full cognizance of all economic factors as it ignores the costs of fishing and the value of the catch.

8/ MScY as the objective of fisheries management takes full cognizance of the likely conflict between income and employment objectives (more employment may lead to overfishing and a reduction of the aggregate fishing income). Employment objectives may be weighted more heavily than income objectives only when there are no other effective means of redistributing income to lower-income groups.

2.1 Biological aspects

2.1.1 The single species, single gear, single community model

While fisheries biology is a science in itself, the fishery administrator needs only to be familiar with some basic biological concepts and relationships of direct relevance to fisheries development and management. In the simplest case of a single-species, single-gear fishery, the relevant relationship is the one between "sustainable catch" and "fishing effort". Sustainable catch is the quantity of fish in terms of weight of biomass which can theoretically be caught year after year without a change in the intensity of fishing. Fishery managers are interested in the sustainable catch rather than any temporary changes in the catch because fish, being a renewable resource, is capable of being harvested on a sustainable yield basis. Fishing effort, on the other hand, is a composite index of all inputs employed for the purpose of realizing this catch. Fishing effort is understood in effective rather than nominal terms, that is, in terms of its effect on the fish stock. (Often fisheries biologists use the term fishing mortality to denote effective fishing effort.) We are interested in effort because it is the main parameter under the control of man.

The relationship between sustainable catch and effort is a basic production relationship relating output (catch) to inputs (effort) but, unlike other production relationships, there is no direct relationship between output and fishing effort. This is due to the fact that fishing effort, while the only input supplied by man, is in fact combined with a natural resource, the fish stock, to "produce" catch. Were the fish stock a fixed factor, just like land, we would expect output to continue increasing (though at a decreasing rate) in response to increases in effort except at the extreme point of overcrowding when output might actually decline. However, the fish stock being a living resource, rather than a fixed factor, reacts to changes in fishing effort in a manner which complicates the catch-effort relationship. Hence, to understand this relationship, some basic biological features of the resource need to be considered.

A basic biological concept is the "net natural growth" of the fish stock which is the net increase in the biomass of the fish population between two points in time. Net natural growth (henceforth "growth" for brevity) is equal to recruitment (new young fish entering the stock) plus individual growth of fish already in the stock minus natural mortality. The growth of the stock is an important concept because it is the amount of fish which can be caught on a sustainable basis without affecting the size of the stock. Hence, it is important to know what determines the growth rate of a given fish stock.

One theory, known as the Schaefer Growth Model, postulates that the growth of a stock of fish depends on the size of the stock 9/. At a small stock size, the growth is small but it increases as the stock becomes larger until a point of maximum growth is reached beyond which growth declines with further increases in the stock due to limits placed by environmental factors (food, space, etc.). This implies an inverted U-shape curve as shown in Figure 1, with the same growth obtainable at two different stock sizes: at a small stock size growing relatively fast and at a large stock size growing relatively slowly.

Fishing effort enters the model as a form of fishing mortality in addition to natural mortality. The larger the fishing effort, the higher the fishing mortality and the lower the (equilibrium) size of the stock. That is, there is an inverse or negative relationship between fishing effort and the size of the standing stocks: as effort expands the fish stock shrinks as shown in Figure 2.

By combining this negative relationship between equilibrium stock and fishing effort (Figure 2) on the one hand, and the inverted U-shape relationship between net natural growth and stock (Figure 1) on the other, we obtain a U-shape relationship between growth and fishing effort (Figure 3). Too little

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9/ More complicated models such as Beverton and Holt (1957) and Ricker (1958) consider the age structure of the stock and the effect of fishing on recruitment. These models require detailed biological data on individual growth rates, recruitment, natural mortality, size at first capture, etc., which in many cases are not readily available. These models have been discussed in detail elsewhere (Gulland, 1969; FAO, 1978; Pauly, 1979 and 1980). Here, we review the simple Schaefer (1954) model with extensions, where possible, to account for factors such as the effect of fishing on recruitment, the age structure and the species composition of the stocks.

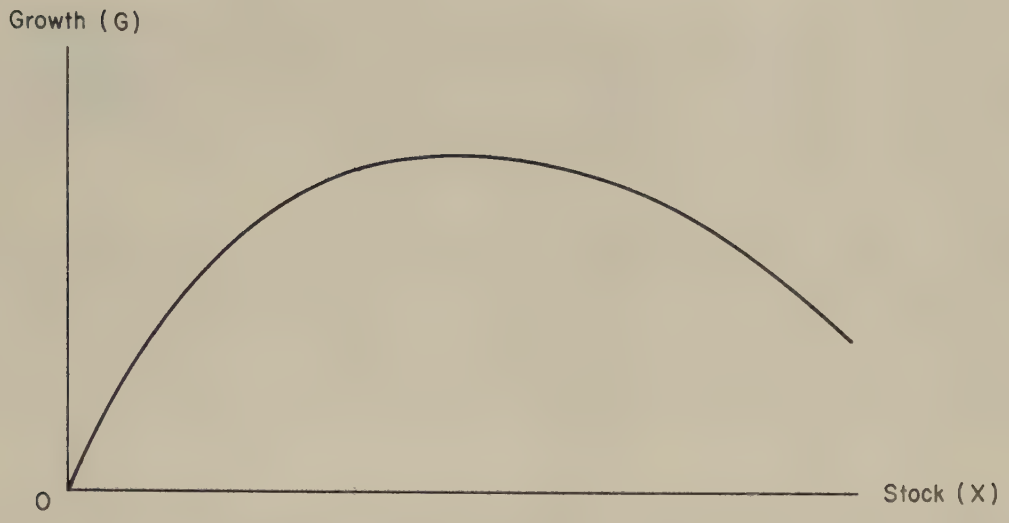

Figure 1 Growth - stock relationship

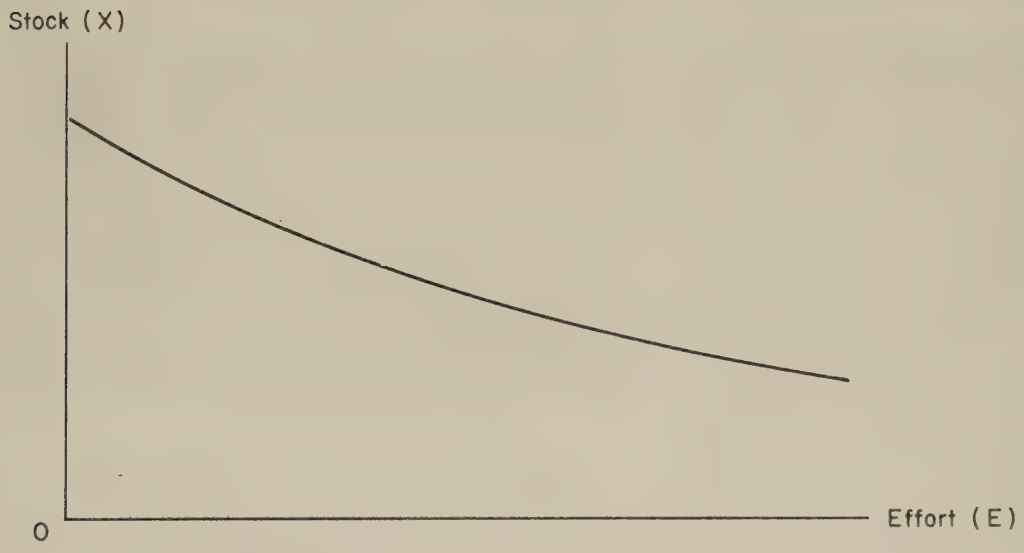

Figure 2 Stock - effort relationship

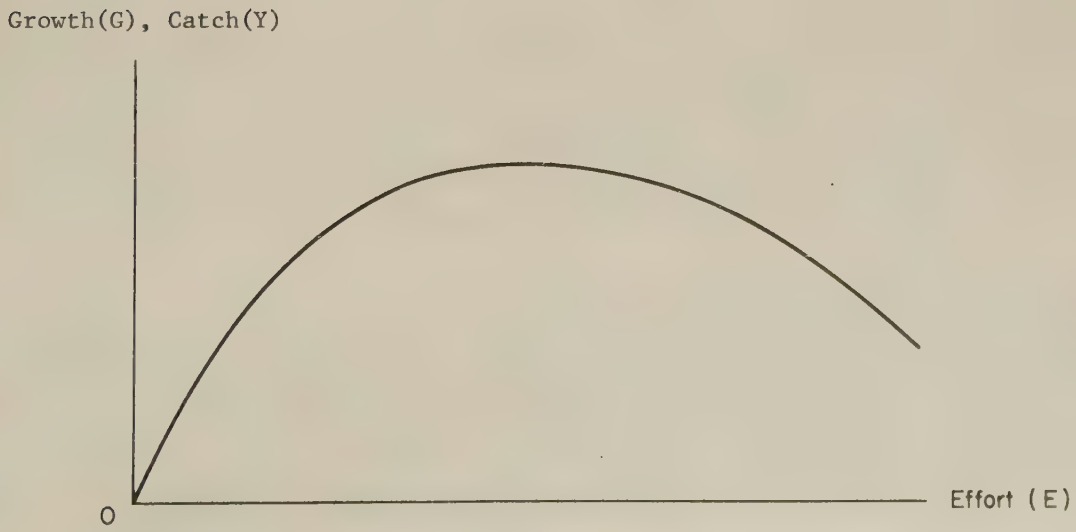

Figure 3 Growth-effort and catch-effort relationships

effort means too large stock and hence too little growth (because of overcrowding); more effort means smaller stock (less crowding) and hence higher growth; but, too much effort results in too little stock and hence, again,in too little growth. Since the sustainable catch exactly equals growth at the corresponding level of effort, the sustainable catch-effort relationship is identical to the growth-effort relationship. Thus, the same sustainable catch can be caught with little effort operating on a large stock or with a lot of effort operating on a smaller stock.

The fishery administrator needs to keep the inverted U-shape of this curve in mind because it describes the long-term response of catch to changes in fishing effort which is the main variable under his/her control: in the early stages of the exploitation of a fishery, expansion of effort brings about more or less proportional increases in catch; but the more effort expands the smaller the growth in catches until a point, known as maximum sustainable yield (MSY), is reached beyond which additional effort reduces, rather than raises, the sustainable catch. This is not to imply that it is not possible to catch temporarily more fish by increasing effort beyond the level corresponding to MSY; however, such increases in catch cannot be sustained over the long-run, at least not by the fishery as a whole.

Temporary increases in catch following an expansion in fishing effort should not mislead the fisheries administrator into believing that there is still potential for further intensification of fishing. Only when the increase in catch is shown to be sustainable over time is there scope for expansion and, yet, it should be noted that even in an underexploited fishery, as fishing is intensified, additional effort brings forth smaller and smaller increases in catch as MSY is approached.

The diminishing efficiency of effort as exploitation increases can be seen more clearly by expressing catch per unit of effort (cpue) as a function of effort. This is done by dividing the vertical coordinate (catch) of the sustainable yield curve by its horizontal coordinate (effort) to obtain cpue which is then plotted against effort as shown in Figure 4. The resulting curve, known as the catch rate curve, steadily drops as fishing effort increases, reflecting the reduction in the biomass of the stock as fishing is intensified. As we have indicated earlier, at moderate levels of effort this reduction in the biomass might enhance rather than damage the stock's capacity to reproduce, because of the resource's intrinsic compensatory mechanisms. However, when fishing is intensified beyond the MSY the compensatory mechanisms fail to maintain the productivity of the resource. The progressive decline in sustainable yield beyond MSY has two causes: firstly, if the size at first capture and more generally the age structure of catches is not modified, the yield per recruit tends to decline beyond a certain level of fishing effort; in addition, average recruitment into the stock, and so the sustainable yield produced by that recruitment, tend also to decline when the parental stock is reduced by heavy fishing to very low levels.

Both the sustainable yield curve and the catch rate curve (Figure 4) were drawn on the assumption of a given age at first capture or a given age structure of the catch. They can be shifted up or down by manipulating the average age at first capture through a variety of means such as changes in the mesh size or in the type of gear, or spatial and seasonal distribution of effort (see Figure 5). For example, reductions of trawl mesh size up to a point may increase catch above certain levels of effort and raise the sustainable yield curve, but too fine nets have the opposite result. In open-access fisheries, where the race for the limited resource often leads to very fine mesh sizes as well as fishing in spawning and nursery areas and seasons, there is an appreciable scope for raising the yield curves through raising the age at first capture. From Figure 5 it can be seen that the higher the fishing effort is, the higher is the gain in sustainable yield to be accrued from an increase in mesh size; in other words, the justification for mesh size regulation increases as fishing effort goes up. Thus, a second parameter which the fishery administrator can control and use to increase the yield from a fishery is the average age of fish at first capture. (As we will see later, this may make a dual contribution to the improvement of the total value of the catch: higher volume of catch and higher unit value for fish of larger size.)

To sum up, a fishery administrator may achieve the maximum possible catch from a fishery on a sustainable basis by simultaneously adjusting the level of fishing effort which corresponds to the highest point on the chosen sustainable yield curve and the age at first capture which puts the fishery on the highest possible sustainable yield curve (Figure 5). It must also be kept in mind that, after a change in either the level of fishing effort or in the age at first capture, sufficient time (depending on the lifespan of the species concerned) must be allowed for the age structure of the stock to stabilize at the new conditions of exploitation.

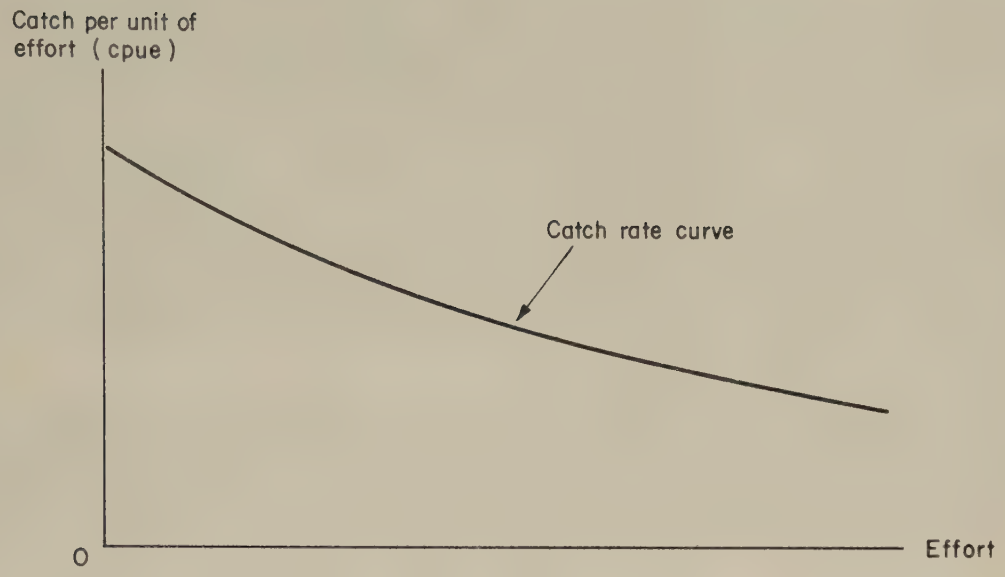

Figure 4 Relationship between catch per unit of effort and effort

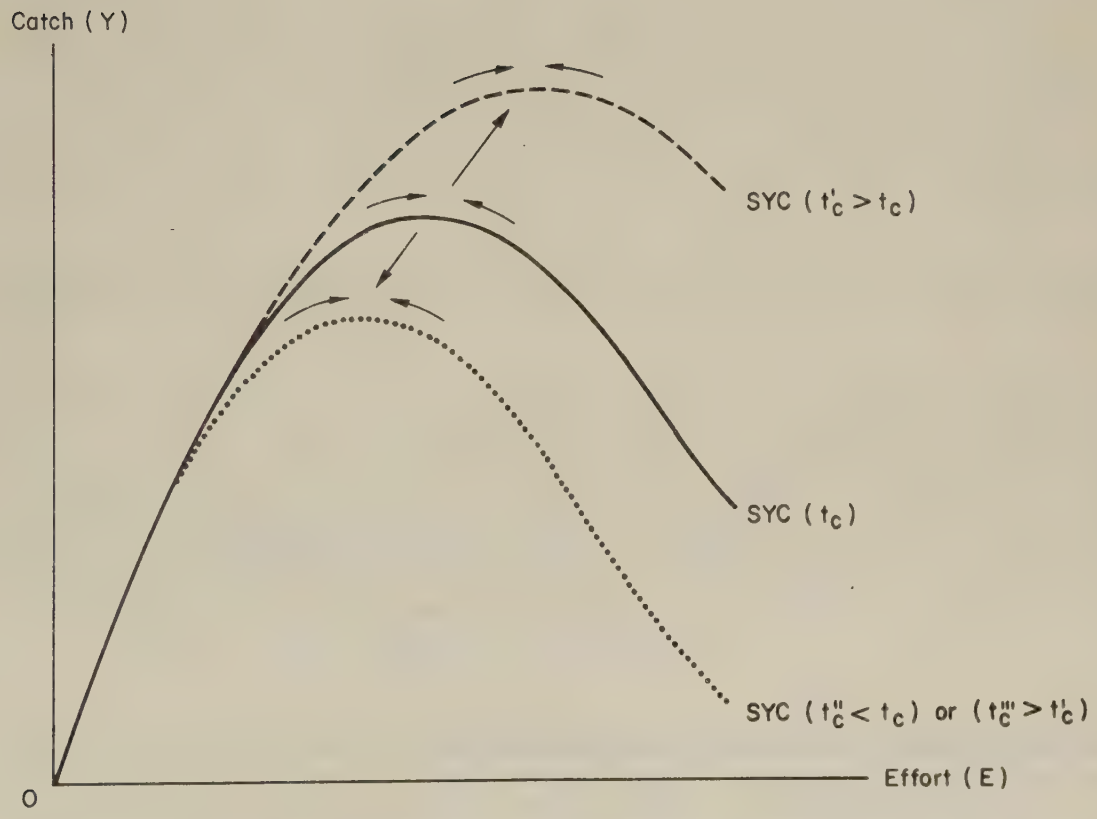

Figure 5 Sustainable yield curves (SYC) under alternative ages at first capture (t_c) and the adjustment of fishing effort and age at first capture for maximizing the sustainable yield from a given stock

The sustainable yield and catch rate curves can become operational, that is, useable in a real-world fishery, by plotting catch and cpue figures from the fishery against the corresponding effort figures. It is often easier and more accurate to do this by specifying a mathematical form for these curves and estimating its parameters through statistical techniques such as linear regression. As an example, we have plotted catch and effort data from the demersal fishery of the Gulf of Thailand. We found that the maximum sustainable yield of demersal fish in the Gulf of Thailand is 550,000 metric tons and the corresponding effort about 6 million standard fishing hours 10/. More importantly, we have obtained the intercept and the slope of the yield curve which give, respectively, an index of the virgin biomass and the rate at which this biomass index and the corresponding catch rate have declined with the expansion of effort to the present level. The fisheries administrator can use these values to assess the level of the exploitation of the fishery (whether under- or overexploited) and to predict the change in the cpue and in the sustainable yield in response to a change in effort, keeping in mind that such extrapolations will cease to be valued, as soon as the exploitation pattern, as reflected by the age structure of catches, is appreciably modified.

The accuracy of any long-term forecasts would also depend on the stability of the environment and on the length and accuracy of the time-series on catch and effort used in estimating the catch-effort relationship. In the theoretical model considered above, we have implicitly assumed that environmental conditions remain unchanged or, at most, they are subject to random fluctuations which average out into the discussed (average) yield curves. However, when non-random or evolutionary changes in the environmental conditions, whether favourable or otherwise to the stocks under consideration, are taking place, it is important that predictions consider also the present state of the environment, its likely effects on the strength of the year classes making up the stock to be exploited in the forthcoming years and, as far as possible, its possible evolution. Moreover, some of the year-to-year variability in the size of the stocks and the corresponding sustainable yields may be neither random nor evolutionary but may arise from the intensification of fishing and the consequent reduction in the number of age classes in the stock which, in turn, reduces the in-built stability of the stock (Troadec, 1982). Finally, the natural variability of the stocks depends on their nature and location as well as on their interaction with the biotic and abiotic environment. The stocks of coastal pelagic species show generally more inter-annual variability than do demersal stocks. Tropical stocks consist of generally short-life species but their spawning seasons generally extend over longer periods, thus counterbalancing the stock variability resulting from the fewer number of broods of which they are made; they interact more with their biotic environment (other stocks) than with their abiotic environment (temperature, etc.) which is normally less variable than in the temperate waters (Pauly, 1979). This means that a stock or a species may show considerable annual variability because of (changes in) the intensity of fishing on other stocks or species as well as in its own rate of fishing rather than because of changes in its (abiotic) environment.

The natural variability of the stocks as well as the possible decline in recruitment and the increase in variability associated with intensive fishing suggest that, on purely biological considerations, even MSY may be "too risky" an objective for development or management.

For simplicity of exposition we have been assuming, thus far, a homogeneous fishery in the sense of a single-species stock fished by a single group of fishermen using one type of gear. However, the tropical fisheries which account for the bulk of small-scale fisheries around the world are distinctly characterized by multispecies stocks exploited by distinct groups of fishermen using a variety of fishing gear. These factors certainly complicate the picture and make more difficult the control of fishing effort and the selection of the "optimum" age at first capture, but the basic inverted U-shape sustainable yield curve 11/ still provides a good approximation of the response of the multispecies resource accessible to a community of artisanal fishermen to the expansion of the effort it can deploy.

10/ We have standardized effort using the Research Vessel of the Thai Department of Fisheries as a base gear.

11/ Perhaps, with its top flat portion stretched far out before it turns down. In certain cases the curve may well be asymptotic in most of its relevant range, implying little or no increase (or decrease) in catch with expansion of effort beyond a certain point.

2.1.2 Sequential exploitation and the conflict between fishermen groups

Let us, first, consider the case of a single-species fishery exploited by two different groups of fishermen: (a) a group of small-scale fishermen operating inshore (including lagoons and estuaries) with rather primitive gear such as stationary traps, and (b) a group of trawlers fishing offshore for the same species, all part of the same stock. This means that the two groups of fishermen concentrate on catching fish of different ages since the spawning and/or nursery areas are often situated in lagoons and estuaries from where "maturing" fish migrate to the offshore area. Under these circumstances it might be possible to increase the overall catch (and its unit value) by increasing the age at first capture through redistribution of effort in favour of the offshore fishery. It could even be that maximization of sustainable catch from the stock, taken as a whole, calls for the complete elimination of the coastal small-scale fishery. However, before the fishery administrator decides the fate of the coastal fishery, he/she needs to consider a number of other factors such as the higher cost of catching the same fish when dispersed offshore, the relative social costs of the inputs (capital, labour, fuel, etc.) used by the two fisheries and the alternative employment opportunities available for any displaced coastal fishermen. (These considerations suggest the importance of economic and social aspects of fisheries management to be discussed in sections 2.2 and 2.3 below.) The situation is analogous in the case of two groups of fishermen fishing the same stock in different seasons of the year or with different fishing technologies: a fisheries administrator can always manipulate the technology or the seasonal and spatial distribution of effort as well as its total amount in order to maximize catch but socio-economic considerations may temper his desire to do so.

2.1.3 The multispecies fisheries

Another complication raised by tropical fisheries is the multispecies composition of the stocks and the consequent technological and biological interactions within the fishery. A technological interaction is said to exist when non-discriminatory gear is applied to a stock comprised of several species in which case it is impossible to allocate the overall fishing effort between the constituent species of the stock. A biological interaction, on the other hand, involves either competition between two or more species for the same food or a predator/prey relationship. In certain fisheries, such as those for tunas, the number of species may be small and they may have similar characteristics of productivity, commercial value, and likelihood of capture. However, this is rarely the case in tropical demersal fisheries where it is not uncommon to find more than one or two hundred species in the same haul ranging from almost worthless trashfish to high-value crustaceans. Perhaps more importantly, there is a complex network of competition and predation relationships and differential likelihood of capture and risk of extinction among constituent species subjected to the same overall fishing effort. When a given overall level and distribution of effort over the constituent species are maintained for a sufficiently long time, a certain species composition, age structure, and aggregate biomass are established and reflected in the catch. Changes in fishing intensity alter this ecological configuration of ages, species and overall biomass. It is quite possible that the relative abundance of some species increases while others altogether fall to low levels in the catch. However, total biological extinction is quite unlikely for most species, notably owing to the existence of natural reserves (e.g., untrawlable grounds).

Under these circumstances, trying to maximize sustainable catch becomes a complicated if not a totally elusive task. In fact, it is quite possible that, as the fishery expands, there will be a sequential collapse of certain species and "emergence" of new species, e.g., cephalopods, which had failed to achieve a dominant status in the presence of more efficient and better adapted species. An example is found in Pauly (1979) who reports that flat fishes (Heterosomata) in the Gulf of Thailand had been kept in check by small prey fishes (Leiognathidea) despite the former's superior reproductive capacity. It was only when the small prey fishes were reduced by heavy fishing and by their predators that the flat fishes found an opportunity to proliferate. This hypothesis, if correct, may help explain why the catches from the Gulf of Thailand keep increasing despite the expansion of effort to levels that would imply heavy overfishing in the light of earlier estimates of MSY.

Selection of a single optimum size at first capture is operationally difficult since what is optimum size for one species is likely to be too small or too large for some other species. In a multispecies fishery, a compromise mesh size will be required; certain species will be overexploited and others underexploited depending on the fishing technology and the biological relationships between species. The latter could be particularly complex because competition and predation affect differently the various age groups of different species (e.g., large predators can prey on small pelagic species which prey on the eggs of the former). These complexities obscure the effect of intensive fishing of one species on the abundance of another species.

The task of the administrator in a multispecies fishery is further complicated by the fact that the species composition, the age structure, and the total biomass of the stock do not vary only in response to man-made stresses (changes in fishing intensity), but also as a result of natural stresses. Ecosystems are subject to both short-term fluctuations and evolutionary changes in their composition and geographical distribution, as the experience with several coastal pelagic fisheries has shown (see Troadec, 1982). Given our limited knowledge of the structure and behaviour of ecosystems and of their reactions to man-made and natural stresses as well as the need for simple, easily understood and implementable management schemes, fishery adminstrators should start with a pragmatic and practical approach to management:

(a) Observe the average species and age composition of the catch and monitor its response to changes in the intensity and pattern of fishing (overall increase in fishing effort, modification of mesh size, introduction of new gear types, change in seasonal and spatial distribution of effort, etc.).

(b) Develop a multispecies production model and translate it into socio-economic terms in a manner analogous with the single species fishery, i.e., use the prices of each species as weights to aggregate the multispecies catch obtained at different levels of effort; then, express this aggregate value of catch as a function of total fishing effort to obtain what might be called a total revenue or gross economic yield curve (see section 2.2 below).

(c) Examine whether this gross economic yield curve could be raised through manipulation of the controllable factors, that is, by changing the total level of fishing effort and the distribution of available fishing capacities on the component species through changes in mesh size, type of gear and the distribution of fishing operations over space and time.

(d) Keep in mind that natural variability of the resource base is an inherent characteristic of fisheries that is hardly possible to predict, and that it is extremely difficult to adjust the volume of fishing and processing capacities and the size of fishermen communities to its year-to-year fluctuations.

A multispecies production model may be constructed by summing up the individual yield curves of the component species as shown in Figure 6. The resulting aggregate sustainable yield curve has more or less the same overall shape as the yield curve of the single-species fishery; basically, catches increase with effort up to some maximum and then decline. It is of crucial importance, however, to keep in mind the aggregate nature of the curve; movements along the curve by increasing total effort do not only change total catch and age structure but also its species composition. The kinks on the overall sustainable yield curve of Figure 6 may imply the practical disappearance of certain species from the catch for certain levels of effort. As the variability in the species composition and size of the stock, as well as the risk of irreversible changes, tend to increase with the intensity of fishing, the fisheries administrator needs to be particularly cautious to select fishing rates and catch levels below the aggregate MSY. As we will see below, this is also economically wise since the economic yield curve in a multispecies fishery attains a maximum at considerably lower levels of effort than those necessary to realize MSY. Similarly, when the pattern of fishing (mesh size, spatial and seasonal distribution) has been manipulated to raise the sustainable yield curve through changes in the age structure and species composition of the catch (in a fashion analogous to Figure 5), possible irreversibilities as well as the economic value of the so modified catch should also be considered.

This essentially experimental (or trial and error) approach to multispecies fisheries management is probably the only option available at the current state of knowledge and management capabilities. It has the added advantage that it involves considerable learning by doing and it is amenable to modifications as new knowledge is accumulated and management capabilities improve.

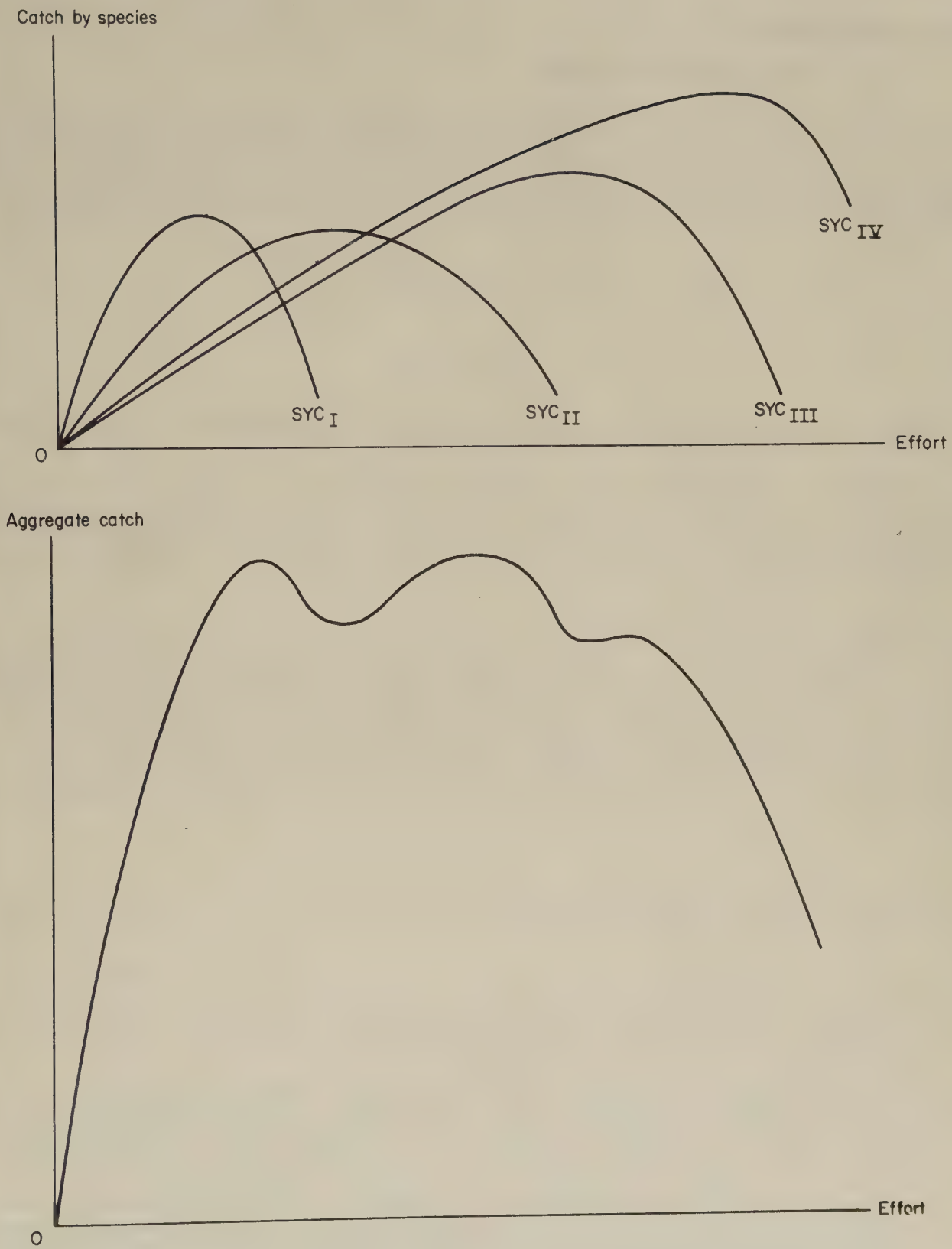

Figure 6 Derivation of the aggregate sustainable yield curve for a multispecies fishery through vertical summation of the individual sustainable yield curves of the component species. The waves in the aggregate SYC signify the dwindling of the share of the indicated species in the catch at certain levels of fishing effort.

2.2 Economic aspects [12/]

2.2.1 The static constant-price model

While it is possible to obtain an aggregate sustainable yield curve for a multispecies fisheries (see Figure 6), it does not provide us with a meaningful management tool. A more appropriate device, as we have cause to suggest earlier, would be the gross economic yield or total revenue (TR) curve obtained by multiplying the catch of each species (at different levels of total fishing effort) by its unit price, summing up over all species, and expressing the resulting aggregate value or total revenue as a function of total fishing effort (see Figure 7).

$$TR = P_1Y_1(E) + P_2Y_2(E) + \ldots + P_nY_n(E)$$

$$= \sum_{i=1}^{n} P_iY_i(E) \qquad (1)$$

where, $Y_i(E)$ is the catch of species i expressed as a function of total fishing effort, P_i is the unit price of species i, and n is the number of marketable species in the catch.

Notice that the TR curve in Figure 7 attains a maximum at a lower level of effort than the sustainable yield curve, suggesting the possibility of raising the volume of catch at the expense of its value through intensification of fishing. This will result from a reduction of the unit price of fish species as their average size declines as the intensity of fishing goes up as well as, in certain fisheries at least, by the replacement of valuable species by less valuable ones. [13/]

Next, we need to introduce fishing costs. Fishing effort is an index of fishing inputs, such as vessel, engine, crew, fuel and other operating costs as well as fishing time. Since some of these inputs are correlated, we need only use those which best represent the catching power and its utilization. Often the product of the tonnage or the horsepower with fishing time is used. Further, since a variety of types of fishing gear are used, it is necessary to standardize effort by expressing the effort expended by the various types of gear in terms of the effort of a base gear which is preferably one whose catching power and pattern of fishing has remainded unchanged for a long period of time (for details and an example, see Panayotou and Jetanavanich, 1982). Assuming that a standard unit of effort, say research vessel hours, has been constructed, we proceed to specify the following fishing cost equation:

$$TC = c \cdot E \qquad (2)$$

where c is the average cost per unit of effort assumed, for simplicity's sake, to be constant. Equation (2) may be graphed as the straight line of Figure 8. [14/]

12/ Throughout this section we are assuming a well-functioning economy with plenty of non-fishing employment opportunities and no serious social problems. We will relax these assumptions in the following section where social considerations are introduced.

13/ One cannot preclude a priori the possibility of heavy fishing pressure resulting in the replacement of low-value predators by high-value preys as in the case of flat fishes in the Gulf of Thailand referred to earlier. In such case, the TR curve may continue rising beyond the MSY level of effort but not ad infinitum. Sooner or later, a point is reached beyond which additional fishing effort brings a reduction in the volume of the catch or its unit value or both.

14/ It should be noted, however, that the directly proportional relationship between cost and effort depicted by equation 2 and Figure 8 and employed henceforth is a simplication for expositional purposes. In most cases, the true cost curve would be curved or sigmoid since the composition of effort would be different at different levels of effort; as effort expands there are economies of scale up to a point and diseconomies of scale beyond. Introduction of these complications does not change our qualitative results but it does matter quantitatively and, furthermore, it has distributive implications.

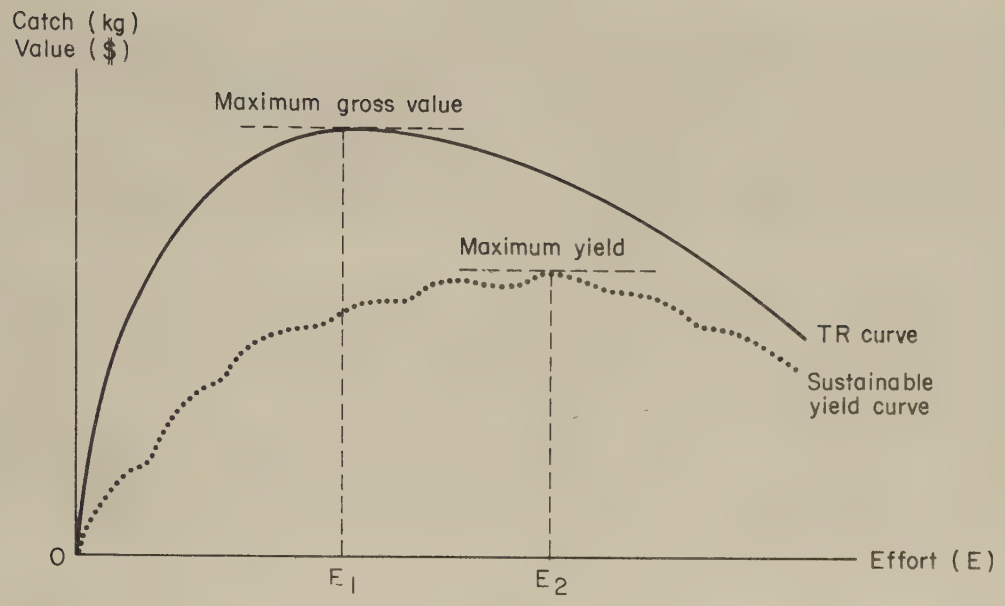

Figure 7 The gross economic yield or total revenue (TR) curve of a multispecies fishery constructed by multiplying the catch of each species by its price and summing up over all species, or by multiplying the aggregate sustainable yield curve by the average price of catch. Notice that the maximum value can be attained at a level of effort lower than that required for the maximum yield. At the maximum yield the value of catch is less than the maximum.

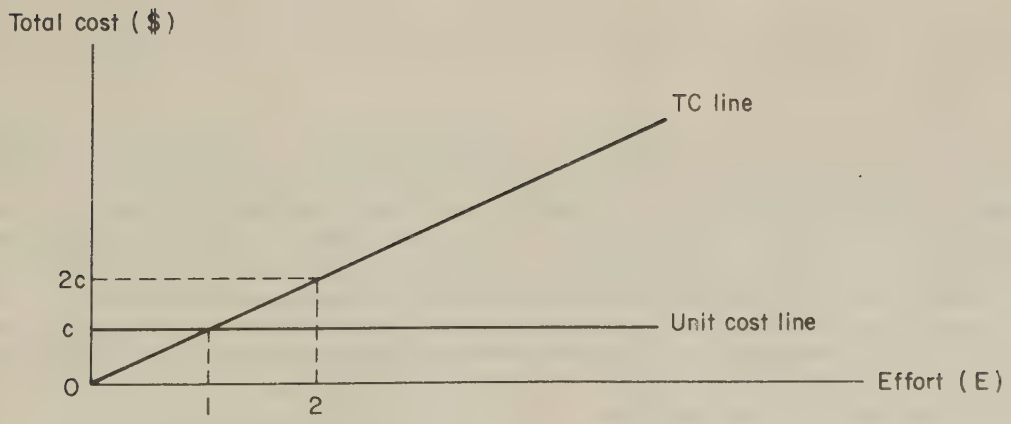

Figure 8 Total cost (TC) line - a proportional relationship between cost and effort

Putting revenues and cost together, we obtain a complete bio-economic model in which the net economic yield or resource rent (Π) is obtained as the difference between revenues and costs:

$$\Pi = TR - TC = \sum_{n=1}^{n} P_i Y_i(E) - cE \qquad (3)$$

As shown in Figure 9, the net economic yield is maximized at the level of effort E_1 for which the slope of the total revenue curve equals the slope of the total cost curve. At this level of effort the last hour of fishing brings in a catch whose value (MR in Figure 9) is exactly equal to the cost of catching it (MC in Figure 9). Each of the previous units of effort brings in a catch whose value is higher than its cost while every unit beyond E_1 brings in a catch whose value is less than its cost. A wise owner or manager of a fishery will expand fishing effort up to E_1 since, up to that point, every additional unit of effort adds to the profits, but he/she will not allow effort to go beyond E_1 since every unit of effort beyond E_1 adds more to the cost than to the revenues and hence it lowers profits (see Figure 9). 15/

In the absence of social considerations (see Section 2.3 below), the maximum profit obtainable at E_1 level of effort and known as the maximum net economic yield (MEY) is the appropriate objective of fisheries management as it ensures that the net benefit to the society from the fishery is maximized. In a multispecies fishery, MEY further reduces the risk of valuable species disappearing from the catch (except in those cases where their disappearance gives rise to other species of higher net value). Thus, MEY is preferable to the elusive MSY as the objective of fishery management, not only from the economic point of view 16/, but also from the ecological point of view since, ecologically, a greater diversity of species has greater chances of being achieved for lower intensities of fishing. The latter has the added advantage of maintaining flexibility (more options open) in the light of the possible irreversibility of "extinction" of certain species about which we know very little.

As we will see in more detail in the next chapter (Section 3.3), MEY is not tenable in an unregulated open-access fishery. The absence of property rights over the resource and the presence of surplus profits (resource rents) at MEY would encourage existing fishermen to expand their effort and others to take up fishing until all surplus profits are completely dissipated in excessive effort. Expansion of effort would only cease when total revenues just equal total costs and, hence, there are no surplus profits (resource rents) to attract new extrants. The level of effort (E_3 in Figure 9) which generates zero resource rents (zero net economic yield) is known as a "bio-economic equilibrium", because at this point both the stock (bio) and the industry (economic) stabilize. From the biological point of view, at E_3 there is overexploitation of young fish known as "growth overfishing" and a risk of an overexploitation of the parent stock and chronic drop in recruitment known as "recruitment overfishing". 17/

15/ This is, however, true only under static conditions, i.e. assuming instantaneous adjustments of fishing effort and of fish stock. As we will see a few pages below, when discussing the dynamic model, consideration of the time involved in these adjustments justifies expansion of effort beyond E_1 but rarely beyond E_2.

16/ The often advanced argument that attainment of MSY is preferable to MEY when people are hungry because it supplies more protein is clearly not valid as long as money can buy protein. This is so because the extra effort (capital and labour) required to catch the few extra tons of fish can produce many more tons of protein from other sources such as aquaculture and livestock. For example, an increase in effort in Figure 9 by one unit, from E_1 to E', will incur a cost of aE' dollars worth of protein from other sources (opportunity cost of effort) to produce additional protein from the sea worth only bE' dollars. Therefore, if money can buy protein, MEY gives the maximum amount of protein. Of course, if there are overriding distributional problems which the authorities cannot solve otherwise, deviations from MEY toward MSY may be justified, as we will see in the next section.

17/ Of course, biological overfishing of either kind is not a result of the bio-economic equilibrium per se but of the point on the yield curve on which the bio-economic equilibrium occurs.

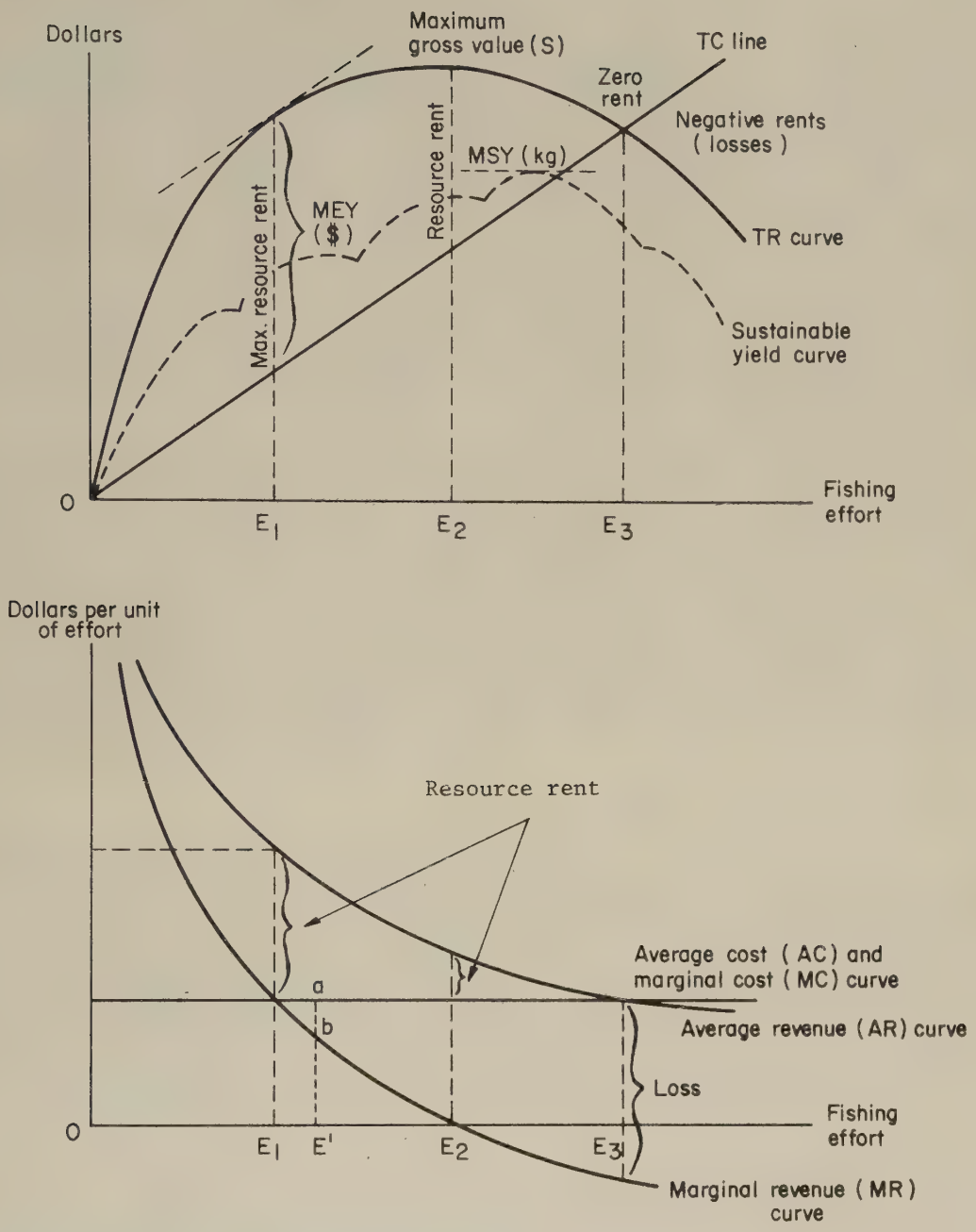

Figure 9 A bio-economic model for fisheries management. Maximum sustainable yield (MSY) and maximum gross value of catch (maximum total revenues) are not the most appropriate objectives of fishery management, as they do not make the best possible use of the fishery resource even if the objective is maximum protein (from all sources). The maximum resource rent or maximum (net) economic yield (MEY) is obtained at E_1 level of effort where the marginal revenue of effort equals the marginal costs of effort. This level of effort, however, is not tenable in an unregulated open-access fishery which gravitates towards a much higher level of effort (E_3), where all resource rents are dissipated. (Note that the average cost and average revenue curves show, respectively, the cost and revenue per unit of effort at each level of effort, while the marginal cost and marginal revenue curves show, respectively, the change in total cost and total revenue, resulting from a change in the level of effort. For more details on this construction, see Anderson - 1977.)

In purely economic terms and solely with regard to the natural resource, at E_3 the fishery ceases to be a "resource" since it generates no resource rents. All resource rents are being wasted to pay excessive numbers of fishermen for their labour and investments which, without these rents, would have earned incomes far below those paid by other similar occupations. That much effort (consisting of scarce capital and labour) is being wasted at E_3 is evidenced not only by the fact that the average returns from a valuable resource barely cover the costs of its exploitation but also (and more strikingly) by the fact that the marginal returns at E_3 are far below the marginal costs and the average returns. In fact, at E_3 the marginal returns are negative which implies that we can increase total revenues by simply reducing effort. Thus, shifting these excess resources (E_1, E_3) away from the fishery towards other sectors would not only generate a surplus value (rent from the fishery) but it would also increase production and income in those other sectors 18/, a prospect which underlines the importance and potential contribution of fisheries management to the overall national economy and well-being. In fact, in an actual economy, the potential benefits from fisheries management may even be greater since the process of entry into the fishery might not stop where all rents disappear but continue into the 'red', beyond E_3, where fishing costs exceed the total value of the catch, and hence fishermen on the average do not earn even as much as they could earn from other occupations.

How could this happen? One reason has to do with the fact that investment decisions are made on over-optimistic forecasts of yield based either on proportional extrapolation of past yields or on exceptionally good fishing years. Since fishermen make their investment decisions quite independently from each other and since the economic life of a vessel is quite long, over-investment is very likely. Moreover, once built, a fishing vessel is, to a large degree, a "sunk" cost and would keep operating whether it covers its fixed cost (depreciation and interest on capital) or not, as long as it covers its operating costs. Another reason for the expansion and sustenance of effort beyond the bio-economic equilibrium with consequent negative resource rents is the tendency of governments to subsidize (directly or indirectly) the industry, thereby lowering the private cost of fishing below its true social cost. Finally, fishermen may be earning incomes below their opportunity costs because of geographical and occupational immobility, itself the result of a host of socio-cultural factors to which we turn our attention in the following section.

2.2.2 The static variable-price model

The model on Figure 9 is a fixed-price model in that the price of each species is assumed to be independent of the size of the catch. This is not an unrealistic assumption for small-scale fisheries which, while employing the majority of the fishermen, land only a fraction of the total catch. There are cases, however, like Indonesia where virtually the entire catch is landed by small-scale fishermen. We could still use the fixed-price model if we are dealing with only a small part of the Indonesian fishery. At the national level, however, we need to introduce a flexible-price model. Depending on consumer preferences and import and export possibilities, the average price of all species combined will be relatively high at low levels of catch and relatively low at higher levels. As fishing effort expands, a number of forces are at work whose net effect may raise or lower the average unit price of the catch; at low fishing intensities, increases in catch tend to lower the averge price and economies of scale from the expansion of operations also tend to reduce it; at high fishing intensities, the drop in catch tends to raise the average price while the reduction in the size of fish caught tends to lower it.

As the more valuable species become relatively scarcer or may, in some cases, disappear from the catch with the intensification of fishing, their prices rise resulting in substitution of less valuable species for more valuable ones, the extent of substitution depending on tastes and incomes. As a corollary, the rise in the prices of conventional species encourages the development of methods of improved utilization of non-conventional species which is encouraged further by economies of scale made possible by their surge in quantities. In reality, the shape and position of the TR curve may change very widely, but for theoretical purposes, the general shape can be assumed to be similar to that of Figure 9. 19/

18/ This is a theoretical possibility which depends on the opportunity cost of labour, mobility and alternative sources of employment which must be investigated for each individual fishery. However, properly defined, the curves of Figure 9 incorporate all these factors.

19/ More appropriately, the demand function for each species could be estimated using data on quantities demanded at different prices (of the species concerned and of its close substitutes) as well as information on consumer preferences and incomes. (For more details and an example from Thailand, see Panayotou and Jetanavanich, 1982.)

2.2.3 The dynamic model

Thus far, we have been implicitly assuming that changes in effort and adjustments in stocks could be made instantaneously. Profits attract new entrants, losses cause exit, and stocks are reduced with entry and increased with exit with corresponding changes in net natural growth. All these changes have been assumed to take place in zero time. In reality, exit, entry, stock adjustment and growth all take time and "time is money". In multispecies fisheries, changes in the composition of the stock as a result of fishing also take time. The idea is that benefits which materialize later on, as opposed to now, should be appropriately discounted because there is always a cost to waiting. Analogously, costs which are incurred in the future are not as painful as costs incurred today.

Whether an action, such as allowing a fish stock to recover from overfishing, should be taken depends on whether the benefits of waiting exceed the cost of waiting. The crucial determinants of these benefits and costs are the growth rate of the biomass, the discount rate and the rate of depreciation of fishing assets. In the case of multispecies fisheries, one should consider both the growth rates of the individual species and the rate at which a certain species composition is altered or reconstituted. The proper goal of management is the maximization of the present value of net revenues over the life of the fishery. This gives rise to a dynamic maximum economic yield (DMEY) which is obtained by expanding (or reducing) effort to the point where the last unit adds to the present value of the stream of future revenues as much as it adds to the present value of the stream of costs. It can be shown that the DMEY is located somewhere between the (static) MEY and the open access equilibrium depending on the rate of discount. If the latter is zero, then DMEY = MEY. If, on the other hand, the discount rate is indefinitely high, DMEY = open-access equilbrium.

While the idea behind DMEY is fairly simple and appealing, its application is limited by the complexity of its mathematical formulation and its relatively greater data requirements (compared to available statistics in developing countries). For this reason, we will not attempt to develop or apply a dynamic model to small-scale fisheries. However, we will, on several occasions, utilize some of the concepts and ideas behind the dynamic model.

2.3 Social considerations

Up to this point, we have been concerned with models which attempt to maximize catch (MSY) and aggregate economic surplus (MEY). We have concluded that in tropical multispecies fisheries MSY is not a meaningful goal for fisheries management. Not only does it ignore the costs of fishing effort but it may also result in a maximum catch consisting largely of trashfish at the expense of more valuable species whose relative abundance may considerably decline in the catch under the heavy fishing pressure required by MSY. We have, then, concluded that the maximum economic yield (MEY) is a more appropriate goal for fisheries management, since it results in maximization of a society's net benefit from the fishery, it keeps more options open in the light of our inadequate knowledge of ecological relationships, and it reduces the risk of collapse of certain species.

Fishery development aims at increasing the exploitation of under-utilized stocks by expanding effective effort through allocation of additional labour and capital, technological upgrading, training, etc. Fishery management, on the other hand, calls for a reduction in fishing effort which, sooner or later, involves the retirement of fishermen and fishing assets. 20/ The implementation of such interventions, though justified on aggregate economic grounds, may be constrained by a variety of social considerations. Since fisheries development and management involve and affect primarily the fishermen, it is necessary: (i) to consider their values, motivations, and attitudes towards the contemplated intervention, and (ii) to examine the distribution of benefits from the intervention between fishermen and non-fishermen, and among fishermen themselves (small-scale vs. large-scale, crewmen vs. boat owners, etc.) in the light of their relative socio-economic conditions. For example,

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20/ Up to this point we are assuming a well-functioning economy with plenty of non-fishing employment opportunities and no serious social problems, in which case MEY is equivalent to maximum social benefit. From this point on we gradually introduce unemployment and other social problems and modify accordingly MEY into maximum social yield (MScY) as the goal of management.

introduction of high-risk high-return fishing technologies may fail, even if subsidized, if the fishermen happen to be risk-averse either by culture or by necessity (at subsistence levels of living, food security is far more significant than a high but uncertain return). Similarly, fishery development may be obstructed by the low social status of fishing vis-a-vis other occupations in certain societies in the same way it can be obstructed by the lack of education and skills to master the required technology for a new type of fishing. Analogously, management involving the retirement of a group of fishermen is unjustified and often non-enforcible in the absence of alternative employment opportunities outside the fishery; if implemented it would have counter-equity implications by imposing a cost on a low-income group in order to generate an economic surplus for the society as a whole (the average-income group).

The introduction of social considerations into the bio-economic model leads to a new concept for fisheries management: the maximum social yield (MScY) which is basically a modified MEY. Introduction of social considerations may limit the speed or the extent to which management measures are introduced, or it may justify more development than is justified on purely economic grounds. This can be best illustrated by the case of an overexploited fishery in a rural economy with severe scarcity of alternative employment opportunities.

2.3.1 Lack of alternative employment

In our bio-economic model we had implicitly assumed that the market prices of fishing inputs (wages, price of fuel, etc.) reflect the true sacrifices which the society incurs in using these inputs (labour, fuel, etc.) in fishing rather than in other occupations. Under these assumptions, attainment of MEY from the fishery may require the reduction of fishing effort by half which, in a country such as Thailand, may mean forcing out of the fishery as many as 35,000 fishermen (or more). How desirable is this when in the rest of the economy there are large numbers of permanently unemployed or under-employed workers?

When there is considerable unemployment, fishing wages do not reflect the true opportunity cost of labour. If, because of widespread unemployment, fishermen have no alternative to fishing, their opportunity cost is close to zero, and therefore the society makes little or no sacrifice in keeping them in the fishery. Therefore, in calculating the cost per unit of effort, c, and the TC curve, we should not include the cost of labour; the wages paid (or other earnings) are not a cost to the society as they represent the utilization of previously unutilized human resources. As shown in Figure 10, the total fishing costs when there is widespread unemployment, TC', are lower than the total costs under full employment, TC, because the former do not include the cost of labour while the latter do. The result is that the 'new MEY' or maximum social yield (MScY) is at a level of effort E_{MScY} considerably higher than E_{MEY} (the level of effort under full employment). Although the surplus profits at E_{MScY} are lower than at E_{MEY} (i.e. dg < ab), the social yield being the sum of surplus profits and wages is higher at E_{MScY} than at E_{MEY} by the amount of df, i.e:

$$dg + gh > ab + bc \quad \underline{or} \quad dg + gh - (ab + bc) = df$$

Thus, df is the net social benefit from allowing effort to expand from E_{MEY} to E_{MScY}. However, expansion of effort beyond E_{MScY} should not be allowed since the social surplus (profits and wages) is reduced. At open-access equilibrium level of effort, E_{OAE}, the social surplus k% consisting entirely of wages is much lower than at E_{MScY} but not necessarily lower than at E_{MEY}. At point m, where TC' = TR, the losses are so high that all wages are absorbed and only capital and running costs are covered by the gross proceeds and hence the social surplus is effectively zero. Thus the maximum social surplus (MScY) is obtained at E_{MScY} level of effort; it is equal to dh and consists of dg amount of surplus profits and gh amount of wages (Figure 10).

If we also take into account that fishing assets (boat and gear) may have no alternative uses, TC shifts even lower than TC' justifying an even higher level of fishing effort but yet lower than the open-access equilibrium level of effort, E_{OAE}. However, as we move away from both MEY and MSY in order to expand fishing employment, the secondary employment generated through the multiplier

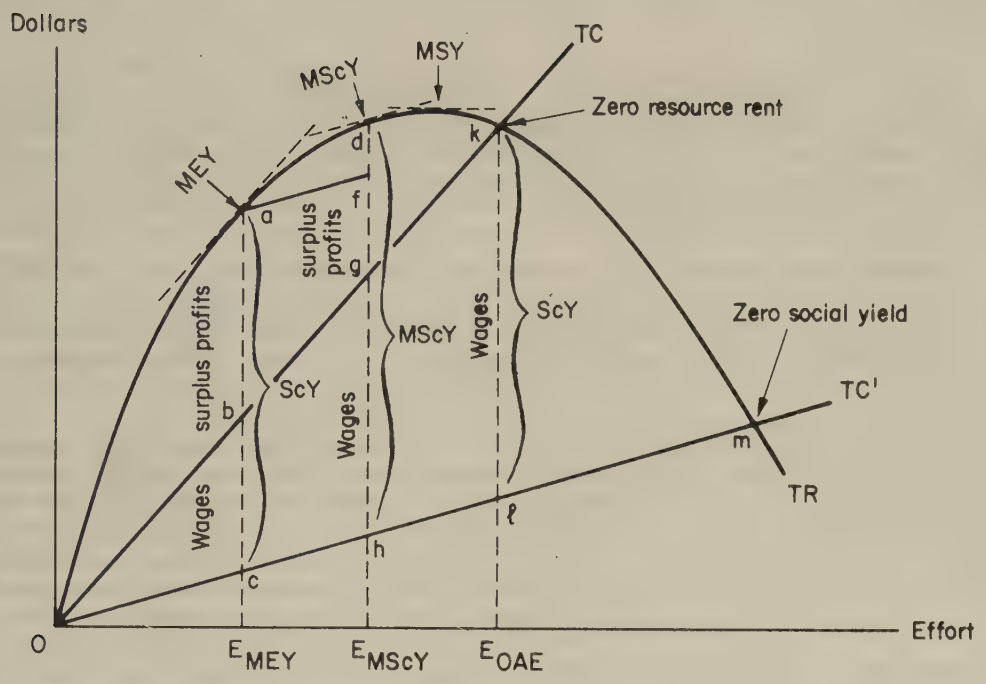

Figure 10 Maximum social yield (MScY) in the absence of alternative employment opportunities. (Note: social yield (ScY) = wages + profits)

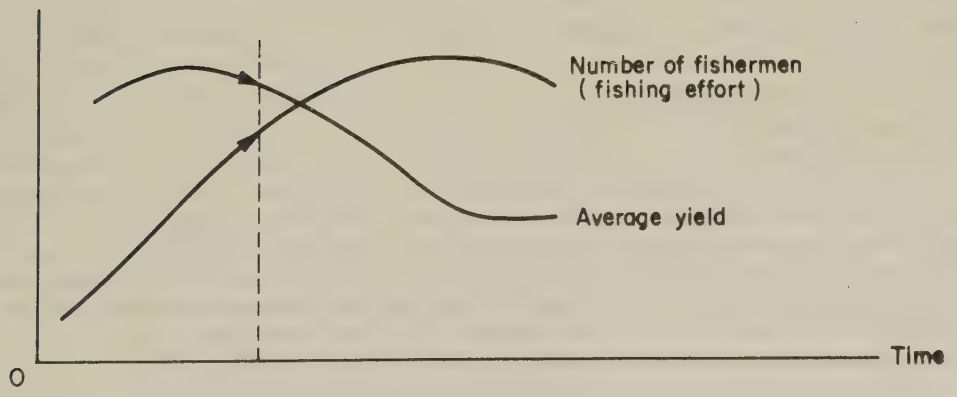

Figure 11 Time lag between the decision to invest in fishing assets (based on over-optimistic forecast of yield) and actual entry into the fishery. The number of fishermen (or fishing effort) keeps increasing even at a time when the average yield is falling and profitability is declining.

effect (fish processing and marketing, non-fishing investment of fishing profits) is reduced 21/ and such reductions may offset any gains in fishing employment. Hence, the maximum social yield cannot be to the right of MSY, even with high priority on the employment objective. 22/

Without attempting to be exhaustive of all relevant social considerations, let us consider three more cases: lack of mobility, subsistence orientation of production, and income distribution.

2.3.2 Lack of mobility

According to our bio-economic model, fishermen will stay in the fishery as long as they earn an income at least as high as the opportunity cost of their labour and capital. As the fishery becomes over-crowded and profits for most fishermen disappear, we would expect those fishermen who are not able to earn from the fishery as much as they can earn from other occupations to slip quietly out of the fishery, changing both occupation and location if necessary, i.e., we assume perfect mobility of labour and capital. This often does not happen.

Lack of occupational and geographical mobility may result from long isolation, low formal education, advanced age, preference for a particular way of life, cultural taboos, caste retrictions, inability to liquidate one's assets, indebtedness or just lack of knowledge and exposure to opportunities. The consequence of immobility is that fishermen may continue fishing even if they earn far less than their opportunity costs.

In fact, many of the socio-economic problems of small-scale fisheries arise from the asymmetry between entry and exit. To enter the fishery, especially in a good fishing year, is relatively easy. 23/ To leave, especially in a bad fishing year, is quite difficult; for one, a fisherman might not be able to afford to spend time looking for a job or moving when his income is down to subsistence level 24/ and, for another, he can hardly expect to find a buyer for his boat and gear during a bad fishing year. During a good fishing year, of course, to leave the fishery is out of the question. It is easy to see how entry during a good year (or a series of good years)and no exit during a bad year (or a series of bad years) would swell the ranks of small-scale fishermen and reduce their incomes to subsistence levels. There is, further, the time lag between the decision to invest in fishing assets, which usually is made when fishing is quite profitable, and the actual entry which may take place when the average yield and profitability have already declined (see Figure 11).

21/ F.T. Christy, Jr. has brought to my attention the case of the flat-topped curves which do not show depletion except at very high levels of fishing effort. This is the case with certain shrimp fisheries and might also be the case with certain multispecies fisheries. In such cases, of course, the secondary employment in fish processing and marketing remains steady with the expansion of primary employment (fishing effort) and secondary employment in vessel and gear construction .

22/ In fact, with zero (social) fishing costs, the maximum social yield is obtained exactly at the same level of effort as MSY. Only if fishing costs are negative from the society's point of view (e.g. danger of riots, social disorder and crime if effort is curtailed) could MScY be at a level of effort higher than that of MSY.

23/ The ease of entry into the fishery differs from country to country and from fishery to fishery. In countries with caste restrictions such as India, or with close communities such as Sri Lanka, entry is more difficult than in more open societies such as Thailand or the Philippines. Entry into coastal fisheries might be easier than entry into offshore fisheries because of lower capital requirements. On the other hand, entry into the offshore fishery might be open to everyone (provided he has the capital and the skill) while entry into the coastal small-scale fishery may be barred by customary or territorial rights. However, restriction of entry from outside the community is not always effective in limiting effort because of population growth within the community. The ease of entry also differs according to the type of fishing: pelagic or purse-seine fishing usually requires more skills than demersal or trawl fishing.

24/ This reason was given by many small-scale fishermen in Southeast Asia interviewed by the author. When asked "if fishing is so bad why don't you take up another job?", they retorted that now they worked more hours to earn a living and had no time to make several trips to the provincial capital to line up a job. It could be that this attitude is more due to a lack of knowledge or of exposure to opportunities outside fishing than lack of time. Still, little is known about mobility in and out of the fishery and further research is called for.

2.3.3 Subsistence orientation of production

Our bio-economic model assumes that the objective of every fisherman is profit maximization. It would not change the results of the model if we replace profit by income. However, it has often been argued that artisanal or traditional fishermen are engaged in fishing not for profit but for subsistence; but, even subsistence is made possible either by consuming one's produce or by selling it for cash income. However, since fish is not a subsistence commodity (i.e. it is not a staple), a fisherman's subsistence depends almost entirely on his income whether as a boat-owner or labourer. Thus, the earnings of income is clearly the intermediate (if not the final) objective of those engaged in fishing.

However, there are two related problems. Some fishermen's objective may be to earn a certain level of income rather than maximize that income. In these cases they behave differently from the fishermen of our bio-economic model who chase every fish which has a price tag higher than the cost of catching it. Fishermen who go after a target level of income reduce their effort when fishing is very profitable (because few fishing trips are sufficient to meet their target) and increase their effort when fishing is poor, a behaviour with grave implications for both fisheries development and management.

2.3.4 Income distribution

In our bio-economic model we have assumed that the purpose of fisheries management from the economic point of view was to maximize the aggregate social benefit without consideration of who gets what. However, given the dualisms that exist in many fisheries, such as small- and large-scale fishermen and boat owners and labourers on the one hand, and the objectives of many governments to reduce income disparities on the other, it is often appropriate to attach a bigger weight to the benefits accruing to small-scale fishermen and crew members than to large-scale fishermen and big boat-owners. This would mean that social benefits would increase as a result of a change in the sharing system which increases the share of the crew, or as a result of a fisheries regulation which allocates more coastal resources to small-scale fishermen by banning trawlers close to shore even if total fishing effort is not reduced and total fishing income has not increased.

As another example, consider the case of the small-scale coastal fishery which catches fish of too young age before it is recruited into the stock exploited by an offshore large-scale fishery. The sustainable catch and its value may be raised by raising the age at first capture through the contraction of the small-scale fishery; but, this is by no means socially desirable if neither income redistribution nor the small-scale fishermen's participation in offshore fishing could be made operational. Inefficiency and waste, especially of open-access resources, could be the price being paid for a tolerable distribution of wealth unattainable by other means in certain socio-political environments. Yet, inefficiency should not be a permanent means of redistributing income; distributional considerations may slow down the speed and temporarily modify the objectives of fisheries management but they cannot alter its long-term objective of rationalizing the fishery for the greatest possible benefit to the society as a whole.

Our discussion of social considerations underlies the need for a closer look on the various constraints under which small-scale fisheries operate (Chapter III) before specific management regulations and assistance programmes (Chapter IV) can be considered.

III. CONSTRAINTS UNDER WHICH SMALL-SCALE FISHERIES OPERATE

In addition to technological, capital and market constraints faced by every economic activity, resource-based industries such as fisheries, forestry and agriculture face natural resource constraints. While agriculture and forestry have been able to mitigate such constraints through technological progress, marine fisheries are still facing (and will continue to face in the foreseeable future) terminal natural resource constraints; there is a maximum quantity of fish that can be obtained from a national fishery, or even from the world fisheries, on a sustained basis. The new ocean regime brought about by the declaration of 200-mile Exclusive Economic Zones (EEZs) has increased the area over which a country has exclusive control of fisheries and hence its maximum sustainable catch (MSY) under the prevailing economic and technological conditions.

Not only is there little that a national fishery can do to break its resource constraint, it has also to live with another constraint: the open-access nature of the resource, which is not found in agriculture or other resource sectors (at least not to the same extent). While land can be parcelled out

and distributed to individual owners who will develop and manage it so as to maximize its productivity and/or economic returns, the sea and its living resources cannot be privately owned because of their fluid nature and mobility. Under open access no individual operator has sufficient incentive (or impact if he had the incentive) to manage the fishery so as to maximize its productivity and/or economic returns. If he did, he would have to bear all the costs alone while receiving only a negligible share of the benefits; he would rather 'over-exploit' the fishery to increase his own benefits while bearing only a negligible share of the cost of overfishing. It is easy to imagine the results when everybody is attempting to do the same. The implications of the open-access status of the resource is that even the limited productivity (MSY) or potential net returns (MEY) cannot be realized without some form of collective management because of the fierce competition which open access induces among the participants. However, management is not costless; it involves costs for research, administration, monitoring and enforcement, as well as political and social costs. Hence, both MSY and MEY overstate the benefits from the fishery since they are not attainable without costs (MSY overstates the benefits by ignoring both the fishing costs and the management costs).

While open access and resource limitations as set by nature and the 200-mile EEZs are more or less common to all fisheries, small-scale fisheries face even more severe constraints. First, their level of technological development confines them to a much narrower area than the 200-mile EEZ. Secondly, their immobility seaward because of limited fishing range and landward because of lack of alternative employment makes them particularly vulnerable to encroachment from both land and sea. Thirdly, small-scale fishermen often face a "mouse-trap" constraint; entry is relatively easy and not very costly 25/, exit is difficult and painful due to a variety of reasons ranging from chronic indebtedness to lack of better alternatives outside the fishery. The purpose of this chapter is to discuss, in some detail, the various constraints under which small-scale fisheries in developing countries operate: resource limitations, open access, lack of alternative employment and conflicts with large-scale fisheries.

3.1 Resource limitations

The limited fishing range of small-scale fisheries confines their area of operation in a narrow strip of sea often not exceeding a few kilometres from the coast. The occurrence and migration of fish into this area determine the resource available to the fishery. The abundance of this resource varies according to environmental conditions and offshore fishing activity. Under constant offshore activity and stable environmental conditions there is a maximum yield that can be obtained on a sustained basis.

In tropical shallow waters, including coastal areas and reefs, there appears to be considerable consistency of yields ranging between 4 and 8 tons per square kilometre, while under estuarine conditions productivity is usually higher, exceeding 10 tons/km^2 (Pauly, 1980) as shown in Table 1.

Table 1 MSY per Surface Area for Selected Tropical Ecosystems

Type of Ecosystem	Location	MSY	Source
Coral reef	Jamaica, Caribbean	4.0 t/km^2	Munro (1975)
	West Indian Ocean	5.0 t/km^2	Gulland (1979)
Shelf	Gulf of Thailand (<50 m)	3.6 * t/km^2	SCSP (1978)
	San Miguel May (<15 m) (Philippines)	8.0 t/km^2	M. Vaxily (pers. comm. to Pauly)
Estuarine conditions	Gulf of Mexico	12 t/km^2	Saila (1975)
	Sakumo Lagoon (Ghana)	15 t/km^2	Pauly (1976)

* Only demersal fish

Source: Compiled by Pauly (1980)

25/ For qualifications see footnote 23 on page 20, and footnote 32 on page 27.

To see how binding resource limitations are, consider the case of the Gulf of Thailand. According to Table 1, the MSY is 3.6 tons/km^2. The coastline of the Gulf is 1,850 km while a strip of 12 km wide is the estimated average distance from the shore accessible to the small-scale fishery. This implies that the demersal MSY available to the small-scale fishery of Thailand is about 80,000 tons. To this we may add another 40,000 tons as the fishery's share of the pelagic resource. 26/ A conservative estimate puts the number of small-scale fishermen in the Gulf of Thailand at 35,000. Therefore, each fisherman's share of the resource is about 3.4 tons per year. In a 1978 survey 27/ of some 320 small-scale fishermen employing 20 different types of gear in the Gulf of Thailand, we found that the average catch per fishing unit ranged between 2.8 tons per year (Southern Outer Gulf) and 3.4 tons per year (Northern Outer Gulf). The catch per fisherman was somewhat higher (3.7 tons) on the Andaman Sea coast where trawling is not possible, and considerably higher (4.6 tons) on the eastern coast of the Inner Gulf where many of the larger vessels have found more lucrative fishing grounds near Kampuchea, leaving the coast to the small-scale fishery.

With an average fishing cost of US$ 0.33 per kg and an average price of US$ 0.60 per kg, this catch enables them to earn an annual income of US$ 750-1,250 or, assuming a family size of six, US$ 125-200 per head compared to an average national per capita income of US$ 400, which could mean 28/ negative resource rents and economic overfishing. 29/ The majority of the fishermen complained that their catch and income have been declining in recent years despite an increase in fishing effort on their part, citing reasons such as increase in the number of fishermen, encroachment by trawlers, low price for trashfish whose proportion in the catch is rising, coastal pollution, etc. A reduction in the average size of shrimp and of other high value species was also reported.

The above scenario indicates that the resource constraint is probably binding and no further development based on the same resource is possible.

What are the prospects for expanding the resource base? There are a number of ways in which resource limitations can be relaxed or at least mitigated: (a) control of gear selectivity and mesh size regulation to raise the unit value of catch (especially shrimp) and to return the fishery on a higher trophic level (more valuable species composition of catch); (b) increase the value of catch through improvements in marketing efficiency and catch utilization; (c) reduction of encroachment by trawlers and other commercial fisheries into the area reserved for the small-scale fishery; (d) reduction of offshore fishing to increase the abundance of the same stocks in the inshore areas; and (e) expansion of the fishing range of the small-scale fishery through technological upgrading. Of these five possible ways of mitigating resource limitations, we will consider here only the first two, leaving the others to be discussed in the next section.

In a multispecies fishery an excessively small mesh size does not only prevent a fishery from attaining its optimum MSY but it could also change the composition of MSY towards less valuable species, as we have seen in the preceding chapter. Selection of an appropriate mesh size (or rather of an appropriate gear) may increase the value of the resource appreciably, even if it does not change the MSY. 30/ This is why estimates of MSY without an indication of its species composition and interaction may be misleading. The attainment of such MSY does not stop the deterioration of the resource and the further impoverishment of the fishermen. The mesh size of 20 mm or less used in most Southeast Asia trawl fisheries, coupled with the intensive levels of fishing, is believed to have been responsible for the documented changes in the composition of the resource. Pauly (1979) reports that the present yield per recruit of Lutjanus sanguineaus in the Gulf of Thailand could be increased by as much as six or seven times by doubling the mesh size, but this would cause a complete escape of a

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26/ Calculated in proportion to MSY estimates (see Panayotou and Jetanavanich, 1982).

27/ See Panayotou et al. (in press).

28/ We say "could mean" for two reasons: (i) this estimate of fishing incomes is based on data for only one year which might have been an exceptional year (time series data are needed); and (ii) comparison with the incomes of other similar socio-economic groups would have been more appropriate than a comparison with the national average.

29/ Similar results were obtained in Malaysia and Philippines (see Librero et al. and Fredericks et al., in press).

30/ However, the need to adopt a compromise mesh size in multispecies fisheries diminishes the effectiveness of mesh size regulation as a management tool. What is needed is selective gear and means of controlling gear selectivity in order to enhance the productivity of the resource base.

smaller species, the Leiognathus splendens. Whether this is an optimal move would depend on the relative value of the two species. If selective fishing is not possible, it is necessary to choose the mesh size, and to consider its effects on the trophic level at which the fishery should operate, that is, the mesh size which will put the fishery on the highest possible total revenue curve (Figure 5).

Even if selective gear was available, Figure 5 still applies as it does in the case of a single-species fishery. There is always an optimum age (or size) at first capture, that is a mesh size which would put the fishery on the optimum sustainable yield curve. The formulation of the mesh-size-selection problem, in terms of total revenue, covers the more general case in which it is necessary to choose both optimum age and optimum species composition.

Regulations on mesh size and fishing methods in general, as a means of mitigating resource limitations in small-scale fisheries, can be extremely important in certain areas. The author has observed (1979) that small-scale fishermen in a village in Trat, the easternmost coastal province of Thailand, were catching large quantities of shrimp 2 cm long, sold at US$ 0.20 per kilogram. They admitted that, if the shrimp was allowed to grow for eight months to a year, its weight would have increased by a factor of 20 and its unit price by a factor of 25. Assuming a natural mortality of 80 percent, during the same period, an appropriate increase in mesh size would have raised the resource value to this group of fishermen by 100 times. Although long-term gains to be expected from mesh size regulations will, in effect, be appreciably smaller owing notably to the need to adopt compromise mesh size in multispecies fisheries, the importance of controlling the selectivity of fishing gear to enhance the productivity of the resource base cannot be underestimated. Yet the fishermen were not willing to increase their mesh size because (a) with a larger mesh size they would have no catch and no income for several months, which they could not afford; and (b) they feared that a larger shrimp will attract the trawlers, as in the past, wiping out both larger and smaller shrimps and any other fish found inshore. Similar arguments were advanced by fishermen using equally destructive gear, such as poison and dynamite.

Thus, much can be done to expand resource availability through improvement in catching methods provided the problem of open access (see section 2 below) is resolved. However, even under current resource conditions, there is scope for improvement in the value of the catch through a more efficient marketing system and improved utilization. The catch from a multispecies fishery (especially an unregulated one) consists of a variety of species and sizes of fish, varying in commercial value according to their utilization. Some species and sizes being completely unconventional as human food are classified as trashfish and are either discarded or sold for fish meal. For example, in Chumporn, Thailand, over 20 percent of the catch of small-scale fisheries in 1978 was classified as trashfish and sold at US$ 0.05 per kg, compared to the average unit value of US$ 0.60 for the entire catch.

Moreover, waste and spoilage of catch in small-scale fisheries are substantial for a variety of reasons: (a) relatively high perishability of tropical fish; (b) lack or inadequate supply of ice and freezing facilities; (c) dispersion and remoteness of small-scale fisheries from the consumption centres. Concurrently, these factors imply high collection, marketing and storage cost and relatively low reservation price for fishermen (once landed, fish must be disposed of immediately). The smallness and dispersion of landing points precludes both economies of scale in the collection of catch and competition among traders, while the remoteness of fishing communities means limited knowledge of market conditions and low bargaining power for the fisherman.

It is possible to reduce the proportion of catch classified as trashfish (including spoilage) and to raise the value of catch by (a) increasing the supply of ice and (b) by promoting the utilization of small sizes and unconventional species for human consumption through processing (e.g. fish paste) or through induced change of consumer tastes. Similarly, the marketing margins could be reduced and the price paid to the fishermen increased through promotion of competition among traders, supply of price information to fishermen and provision of marketing infrastructure such as feeder roads, landing centres and marketing facilities. We are not arguing here that it pays (socially or privately) to do all these or that such measures alone would be sufficient to improve the conditions of the fishermen. The point made here is that improved utilization of the raw material and reduction of marketing margins are possible ways of mitigating resource limitations for the fishery as a whole, much analogous to an expansion of the resource base. Their effect would be a rise in the value of catch depicted graphically as an upward shift in the total revenue curves analogous to the shift caused by an increase in mesh size (see Figure 5). How effective such measures would be in mitigating the resource limitations faced by the individual fishermen over the long run would depend on the institutional and economic conditions governing access and entry into the fishery (see Section 3 below).

3.2 Conflicts with the large-scale fisheries

Not only is the resource base of the small-scale fishery limited by its fishing range and natural productivity, but often it has to compete for this limited resource with other fisheries using more advanced technology. As we have seen in the preceding section, often the resource available to a coastal fishery is also exploited in offshore waters, whether this involves or not clear displacements perpendicular to the coast of different age groups (spawners, juveniles, etc.) of the stock. Large-scale fisheries operating offshore may thus reduce the fish available to small-scale fishermen. Similarly, small-scale fishermen's operations may reduce the recruitment to the offshore stocks. For example, in the Ivory Coast, the lagoon fishing of penaeid shrimp may have caused the economic collapse of the trawl fishery (Troadec, J.-P., pers. comm.). In fact, small-scale fishermen are often more strategically positioned on the biological cycle, but this is generally more than offset by a fundamental asymmetry between the two fisheries: the large-scale fishery can operate both offshore and inshore (with some exceptions) while the small-scale fishery is confined to inshore fishing.

Although large-scale fishing units are often prohibited by law from operating in the coastal area reserved for the small-scale fishery, the presence of high-value species, such as shrimp, and the higher fish densities in shallow waters which characterizes tropical ecosystems as well as increasing fuel costs coupled with enforcement difficulties result in encroachment and open competition between the two fisheries over the same resource. This leads to overcrowding effects and physical conflict between gears such as trawlnet and stationary gear. Violent clashes between the two fisheries have been reported throughout Southeast Asia. In Malaysia, for example, the encroachment by trawlers of the traditional fishing grounds of small-scale fishermen led to about 100 incidents (1970-1973) in which almost 400 trawlers and 800 inshore fishing boats were involved, 60 boats were sunk and 23 fishermen killed (Smith, 1979). In Indonesia, according to the Director-General of Fisheries, after a series of clashes and demonstrations and a court trial of 1,000 trawlers operating illegally in the coastal area, the Government banned trawlers altogether from Indonesia since October 1980 (Sardjono, 1980). In North Yemen, the Government was forced to ban trawlers following demonstrations by inshore fishermen protesting the encroachment of their traditional fishing grounds by company-owned shrimp trawlers and the consequent damage of their gillnets and the dumping of fish back into the sea (Thomson, 1980). Similar clashes and boat-burning incidents occurred in India, Thailand, Philippines and the Ivory Coast.

The two fisheries are also in conflict in the market to the extent that they use the same inputs or catch the same species of fish (or close substitutes). Large-scale fishermen may bid-up the prices of fishing inputs or their massive landings may depress fish prices. While this may raise the welfare of the producers of fishing inputs and the consumers of fish, small-scale fishermen may become increasingly uncompetitive. Under normal conditions, this is an acceptable and efficient process by which the more efficient (low-cost) producers displace the marginal (high-cost) producers. However, for at least three reasons this outcome may be neither efficient nor equitable: (a) market distortions and imperfections especially in the capital market; (b) socially unacceptable distribution of income; (c) lack of alternative employment opportunities for displaced fishermen, and the need to slow down the migration to the cities.

A fundamental condition for fair competition is that the participants have access to the same capital market. In many developing (and some developed) countries, markets are not only fragmented but also distorted by so-called development subsidies. While industrial fisheries have access to low-interest institutional credit and subsidized development loans, small-scale fishermen have only access to informal credit at interest rates many times higher than the institutional rates. For instance, in Chumporn, Thailand, small- and medium-scale fishermen obtain loans at interest rates ranging between 36 and 60 percent 31/ compared to the institutional rates of 8-12 percent (1978), not to speak of development loans at concessionary interest rates. As expected, an expansion of subsidized capital and open-access resources has led to capital intensities (and eventual over-capitalization) unjustified by the prevailing relative endowment position of developing countries (labour-abundant and capital-scarce). It is unfortunate that development's requirements for savings and capital formation has so often been misunderstood or construed to mean mechanization.

31/ These loans are apparently so risky and costly that commercial banks cannot compete effectively even at these high rates; government and institutional ceilings on interest rates, collateral requirements, and strict repayment schedules result in the limited role of institutional credit in the rural economy.

Small-scale fisheries are further handicapped by their dispersion and remoteness which precludes economies of scale in the marketing of catch and procurement of inputs which may only partially be compensated by their low opportunity costs and low capital and fuel costs. Although in social terms small-scale fishermen often may be low-cost producers, in private terms their unit cost may be relatively high because of inadequate infrastructure, and high cost of borrowing. The reverse, of course, might be true of large-scale fisheries if the capital subsidies (explicit or implicit) are removed and capital and foreign exchange (imported machinery, fuel) are shadow-priced at their true social costs. For example, in Trat, Thailand (1978) imported fuel accounted for over 47 percent and (local) labour for less than 28 percent of the total cost of a medium-scale trawler. At the same location and time, fuel accounted for only 19 percent and labour for as much as 55 percent of the total cost of a crab trap. There was no significant difference in the return to capital between the two gear types. The importance of these differences is appreciated only when one considers that Thailand is facing a balance of trade and payments deficit of almost US$ 3 billion and that almost half the country's foreign exchange earnings are spent on fuel imports and that unemployment exceeds one million people, to say nothing of underemployment.

The new ocean regime of extended jurisdiction by coastal states provides an opportunity for "re-allocation" of fish resources between the two fisheries. However, prior to such re-allocation it is necessary to reassess the viability and social profitability of these fisheries using shadow-prices which reflect the true scarcity of factors of production in calculating costs and benefits. Given the existing relative factor endowments in most developing countries and the overcapitalization of large-scale fisheries with distorted prices and open-access, such reassessment would inevitably result in allocation of additional resources to small-scale fisheries which were forgotten under the open-access regime because of their inability to join the race for long-distance resources Of course, such allocation of resources between the two fisheries would involve the technical problem of determining some balance between mortalities in the inshore and offshore fisheries, and a political decision on the distribution of the generated rents in the context of the country's overall development objectives.

Institutional support is often skewed in favour of the large-scale fishermen because of (a) their apparently higher efficiency and (hence) greater "contribution" to economic growth; (b) their ability to concentrate in few landing areas which allow economies of scale in the provision of infrastructure such as landing facilities, roads, etc., and the delivery of assistance programmes; (c) their visibility, political influence, and economic strength; and (d) a general bias in favour of large-scale fisheries under the open-access regime. In contrast, small-scale fishermen are geographically dispersed and isolated and politically unorganized and weak. Because of their technological stagnation and their feature as economic activity of last resort, small-scale fisheries rarely seem to satisfy the conventional investment criteria. However, if distributional objectives are as high in the policy-maker's list of priorities as efficiency objectives, benefits accruing to small-scale fishermen and other low-income groups should be weighted by appropriate distributional weights. Of course, efficiency in the pursuit of distributional objectives should be observed: between public investment projects with similar distributive outcome, the one with the lowest cost in terms of sacrificed 'efficiency' should be chosen.

3.3 Open access and easy entry

In the previous section we have discussed the ultimate or theoretical physical and economic limitations of the resource for the fishery as a whole. In reality, however, there may be even more stringent resource limitations imposed by institutional and historical factors.

Until very recently, world fisheries had been open-access resources in the sense that whoever wanted to take up fishing was free to do so. Under the new ocean regime, open-access within a country's EEZ is limited to the country's nationals. People are attracted into fishing by the prospect of earning an income higher than in other economic activities with more or less the same amount of effort. 32/ How is this possible?

If the alternative to fishing is farming, one needs to purchase or rent the natural resource (land) in addition to capital and labour. In contrast, for fishing, one has free access to the natural resource (fishing ground and fish) and, hence, unlike the farmer, he need not pay a rent to any "sealord"; he can keep it for himself, thus, "appropriating" in a way the resources and making himself a sort of sealord. However, unlike the landlord, he cannot exclude others from appropriating the very same resource; even if he could prevent others from operating in the same fishing ground, he still can do little to

prevent the fish from moving between and being exploited in other fishing grounds. Hence, early entrants into a virgin fishery can reap substantial rents until others, attacted by the same prospect, crowd the fishery to the point that the limited resource is divided into so many shares that most fishermen earn no more than if they took up farming (or whatever other alternatives they were faced with) in the first place. A few fishermen may still earn some profit due to above-average ability or more sophisticated technology but these are not resource rents but rents of ability or quasi-rents arising from the prompt adoption of new technology. Any fishermen who incur losses, by definition could earn a better income outside the fishery and as soon as they can find a good buyer for their boat and gear and a new job for themselves they would be out of the fishery. In the long run and under static conditions, it would be difficult to find fishermen earning either more or less than they can earn from other occupations; there would be no reason for those already in the fishery to leave or for those outside the fishery to enter. 32/

What is wrong with this 'happy' state of affairs? True, everybody is receiving as much as he is entitled to under the system. 33/ Yet, something is lost. If the fishermen earn no more than they could earn elsewhere, if the government earns no tax-revenues from the fishery, and if the society at large gets no special benefit 34/ from the fishery, then what is the advantage to a country of having a marine fishery vis-a-vis a landlocked country? If all sectors of the economy were operated on the same principles (open access and, hence, no surplus value), there would be little funds, if any, to invest in the country's economic and social development.

The benefit of the society from any economic activity (agriculture, industry, fishery) is maximized at the level of effort (use of capital and labour) which gives the largest possible difference between the value of output and the cost of effort (inputs). When secure private property rights exist and the markets are fairly competitive (as in farming), the actions of the individual operator (e.g. the farmer) in attempting to maximize his own income lead (also) to the maximization of the economic yield for the society as a whole even if this was not in his intentions. In fishing, however, because of the lack of secure property rights (open access), the actions of the individual fishermen in attempting to minimize their own income do not result in the maximization of the society's economic yield but to

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32/ It is sometimes argued that it is extremely difficult for people who have never been fishermen and who are not from "fishing stock" to join the fishery even where access is open. It is absurd, however, to think of all fishermen as descendents from some original fishermen. What actually happens is that there are large numbers of people on the fringe of the fishery who have had at some point in their lives some familiarity with fishing either as occasional fishermen or as casual crew members or even as just friends and relatives of fishermen. Others have had some experience in inland water fishing and so on. Yet, others, totally unfamiliar with fishing but facing the prospect of starvation, drift to the coast and offer their services as "casual help" until they amass some experience and the capital to own a net or buy a stick of dynamite. Another form of early entry is coastal "light fishing", a very common sight on Southeast Asian coasts at night. The evidence that fishing is one of the few remaining last-resort occupations is compelling. In section 3.4 we refer to several sources of such evidence. Here, it suffices to quote Ondam (1976:81-82), a sociologist writing about Paknam Lak Suanin Southern Thailand, a non-so-unusual Southeast Asian fishing community consisting of 600 households: "The community is a no-man's land with 53 percent of the population being immigrants, attracted to it by the promise of fishing ... 82 percent of the households own no land ... 70 percent think they will continue fishing forever".

33/ If what we are not happy with is the (free-enterprise) system, there is no reason why we should be particularly concerned with the fishery, which is only a minute part of the total economy.

34/ Of course, the society enjoys a consumer surplus by having large supplies of fish at "low prices" but a consumer surplus is enjoyed from agricultural production as well as from other activities. Moreover, the society is paying dearly for its consumer surplus from fishing through excessive use of labour and capital and hence lower production and lower consumer surplus from non-fishing activities. Protein supplies cannot be counted as benefits since they are obtained at higher cost than they could be obtained from other sources (aquaculture, livestock, etc.). Similarly, employment cannot be counted as a net benefit since fishermen could earn, presumably, the same (low) income in other activities.

its complete dissipation. As long as there is any excess of revenues over costs (positive economic yield), existing fishermen would increase their effort and new fishermen would enter until costs have risen substantially and the resource has been reduced (or its composition changed) by so much that the net economic yield from the fishery is zero, revenues just covering costs (see Figure 12).

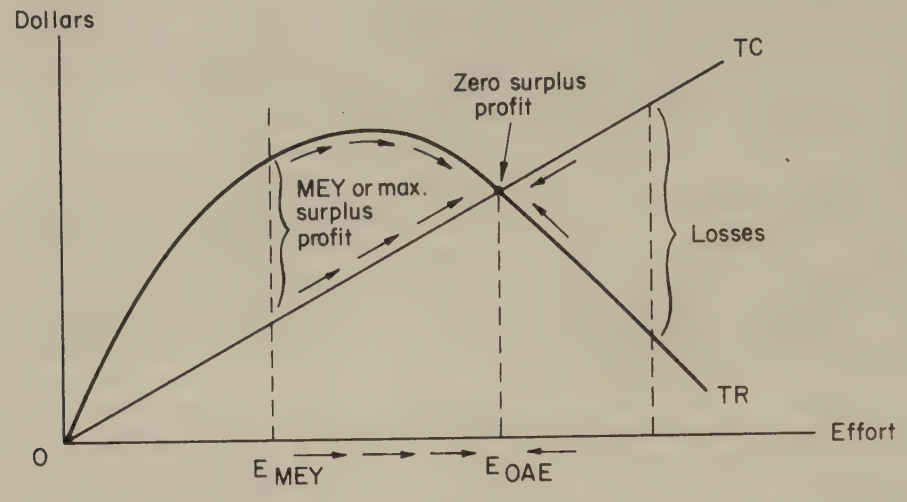

Figure 12 The maximum economic yield (MEY) cannot prevail as a long-term equilibrium in an open access fishery. As long as there are (excess) profits to be made, new entrants would be attracted and effort would expand until a zero-profit or open-access equilibrium (OAE) is reached at E_{OAE} level of effort.

From the above analysis, three policy implications may be derived: (a) an open-access fishery makes little or no long-term contribution to the country's economic development since any economic surplus created is self-destructive through the additional entry it attracts; (b) favourable changes in economic conditions or attempts to further develop the fishery or assist the fishermen, result in further entry and hence a further depletion of the resource or adverse change in its composition; and (c) expansion of the resource base (e.g. EEZ).

Our bio-economic model of Figure 12 would predict that at least in the long run there would be no fishermen earning incomes lower (or higher) than their opportunity costs which implies that fishermen on the average would not be worse off than other similar socio-economic groups in the country. However, there is a fundamental asymmetry in the dynamics of entry and exit. In a good year for the fishery and/or a bad year for the other sectors, many non-fishermen with insecure sources of income (landless farmers, under-employed labourers, etc.) are attracted into the fishery. Of course, there is no reason why the "right" number 35/ would be attracted; it depends not only on the size of the prospective gain but also on the conditions outside the fishery. It is analogous to rural-urban migration; the creation of one job in town attracts several migrants.

Access to the sea, of course, does not imply access to the resource; there may be economic barriers to effective access or entry, such as capital requirement, for boat and gear, as well as skills for operating them. However, the peak occurrence of tropical species in coastal areas and the extreme difficulty in enforcing regulations against the use of destructive fishing methods (poison, dynamite, fine nets in nursery grounds, etc.) imply low private cost of entry. For example, the capital cost of a non-powered boat and gear in Thailand in 1978 did not exceed US$ 40, and in the Philippines US$ 60.

35/ The number of fishermen necessary to bring the fishery to an open-access equilibrium.

In contrast, exit is not as easy. Over the years, substantial fishing and non-fishing assets have been accumulated, skills lost and new acquired, old connections and habits broken and new established that leaving the fishery means more changing a way of life than merely changing occupation. First, fishing assets cannot be easily liquidated in overexploited fisheries. Second, chronic indebtedness and related obligations to fish traders/lenders to continue fishing, common among small-scale fishermen, may impair mobility. Third, small-scale fishermen, being isolated in a remote fishing community, may have insufficient information on the location and nature of more lucrative employment opportunities. Fourth, finding a new occupation/residence and refreshing one's long-forgotten skills takes time, often unavailable to small-scale fishermen who, in the face of declining income per unit of effort, just eke out a subsistence income. Fifth, there may be barriers to entry in other occupations. Sixth, since fishing activities for most small-scale fishermen are integrated with land-based activities (neither of which is sufficient to earn them a living), abandoning fishing means abandoning all other land-based activities, a move invariably described by fishermen as "uprooting". Lastly, but perhaps most importantly, traditional fishing communities have a way of life and a subculture of their own which cannot be easily adapted to fit the requirements of industrial jobs and commercial farming activities (this is why fishermen may make poor fish farmers). 36/

Thus, either because too many fishermen were attracted into the fishery when it was profitable or because profitability declines as a result of subsequent change in economic (or bio-ecological) conditions, it is quite common to find small-scale fishermen earning incomes considerably below their respective opportunity costs. For example, as shown in recent studies, small-scale fishermen throughout Thailand, the Philippines and Malayasia 37/ were found to be among the lowest socio-economic groups, earning incomes considerably below the respective national average and even below what they could earn in alternative occupations. This implies (a) relative poverty and lack of mobility, and (b) negative economic surplus, and hence negative contribution of the fishery to national economic development. In Thailand, most small-scale and some of the medium-scale fisheries were found (1978) to earn negative resource rents, that is, losses up to to US$ 2,500 per fishing unit per year depending on type of gear and location. At about the same time, negative rents were found in the Philippines (especially among motorized boats) and in Malaysia (especially on the west coast).

In contrast, in some small-scale fisheries in Sri Lanka, substantial resource rents were captured due to effective barriers to entry in the form of closed fishing communities (see Fernando et. al., 1982). Persons from outside the community are not allowed access to the fishery which is considered property of the community. No outsider is allowed to dock a fishing craft along the shore line "belonging" to the community. Nor is crew recruited from outside as long as there is labour available within the closed community. This has been the most effective barrier to entry which has kept both the return to capital and the return to labour significantly above their respective opportunity costs, and will continue to do so as long as the community ties are strong and no threat of encroachment by a large-scale fishery exists.

Thus, we may conclude that open access, when combined with the isolation and dispersion of fishing communities and the socio-cultural characteristics of small-scale fishermen, may lead not only to the dissipation of economic surplus for the society at large but also to the impoverishment of the fishermen themselves. Lack of occupational and geographical mobility may result from long isolation, low educational level, advanced age, preference for a particular way of life, cultural taboos, caste restrictions or just inability to liquidate one's assets. However, most often, the reasons behind the absolute if not the relative poverty of small-scale fishermen is the lack of sufficiently attractive alternatives to warrant the cost of change in occupation and the incomparably higher cost of re-settlement in a different social environment.

3.4 Lack of alternative employment

There are two related aspects to consider here: (a) unemployment in non-fishing sectors, and (b) "surplus" labour and lack of non-fishing employment in the fishing communities themselves. As we

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36/ Yet, as C.H. Newton aptly remarked, mobility is ultimately a function of income. Most, if not all, of the constraints to exit enumerated here could be overcome with sufficient income.

37/ For Thailand, see Panayotou et. al. (1982); for Philippines Lebrero et. al. (1982); and for Malaysia, Fredericks et. al. (1982).

have seen in Chapter 2, the presence of chronic or structural unemployment implies low opportunity cost for labour. Inevitably, open-access resource sectors become a reflection of the conditions prevailing in the rest of the economy. If attractive employment opportunities outside the fisheries become available, an outflow of resources (capital and labour) from the fishery to other sectors is induced. For example, certain Red Sea and East African countries face problems in keeping their fisheries operating in the face of better employment opportunities with oil companies (Ben-Yami, pers. comm.). If unemployment and landlessness in the rest of the economy are increasing, the reverse should be expected: there will be a net inflow of labour into open-access resource sectors such as fishing. Naturally, new entrants having little, if any, capital and no experience, take up coastal fishing, thus swelling the ranks of small-scale fishermen. There is considerable evidence that coastal fishing is an economic activity of last resort. For example, Pollnac and Sutinen (1979) report that in East Africa "fishing is viewed as the employment of last resort ... people fish when farming is not feasible" (p. 59). Similarly, Nagata (1980) reports that, after the legalization of (capital intensive) trawling (1965) in Malaysia, a number of displeased fishing labourers "eventually drifted back to the small-scale fisheries, to which entry is relatively easy" (p. 4). Yet another example is found in Cordell (1973) who reports that in Northeast Brazil labourers released from coconut plantations took up canoe fishing for lack of better alternatives at a time when canoe fishing communities were abandoning traditional fishing grounds (estuaries) for swamp fishing under the pressure of competition from more advanced technology. In Southeast Asia, Larsson et. al. (1975) and Collier et. al. (1977) report an increasing trend in the number of small-scale fishermen in Malaysia and Indonesia respectively. Thus, we may conclude that a decline in employment opportunities outside the fishery reduces the opportunity cost of fishing, increasing the dependence on fishing, discouraging exit and encouraging new entry leading to further resource depletion and hence more stringent resource limitation.

What about the availability of non-fishing employment within the fishing communities themselves? Small-scale fishing communities are often found in areas where land-based activities are limited and the transport and communication linkages with the rest of the country are poor. This is further exacerbated by the tendency of small-scale fishermen to be seaward looking with little interest in the national affairs. (For example, in Thailand, fishermen, in general, have repeatedly refused to pay taxes on the grounds that they benefit little from public services and social infrastructure.) It is often true that this isolation was partly imposed on small-scale fishermen by the lack of interest on the part of politicians and administrations, fisheries and otherwise. Small-scale fishermen are often too dispersed and politically and economically weak to lobby for their interests. 38/ The consequence of this chasm between small-scale fishing communities and the rest of the country is manifested in the paucity of fishing-supportive infrastructure and services and in the availability in non-fishing employment. Yet, invariably, small-scale fishermen derive a small but crucial portion of their incomes from non-fishing activities such as farming, small-businesses and trade. These occupations (along with land-based fishing related activities such as net mending, fish drying or processing, etc.) absorb the considerable fluctuations in fishing activity arising from environmental conditions (weather, seasonal fluctuations, poor fishing gears, etc.).

However, since these land-based occupations require at least land and markets, they are faced also with terminal constraints by virtue of the limited size and productivity of the coastal strip originally occupied by the community and by the transport and other links of the community with the rest of the country, which are invariably poor. Population growth within the community and any migration from outside (when fishing is still profitable) provides for a larger local market but, with fixed resources (fish and land) and little capital formation or productivity improvement, the purchasing power remains limited, except in times of exceptional catch. Expansion of fleets and motorization of fishing boats did advance considerably in recent years representing both accumulation of capital (or at least access to credit) and technological upgrading. However, much of recent motorization did not produce the expected result since it took place in areas where the resource was already "overexploited" and further extension of small-scale fisheries fishing range brought them in conflict with the offshore fishery.

38/ The extension of jurisdiction has changed this in some parts of the world, e.g., Canada and Indonesia, where small-scale fishermen have begun to exert some political power. In other countries, such as Thailand and the Philippines, small-scale fishermen continue to be economically as well as politically among the weakest socio-economic groups.

Thus, in a way, small-scale fishing communities are both "land-locked" and "sea-locked", with unparalleled fixity of resources: fish, land, markets and connections to the outside world. While in many countries the influx from outside may have nearly dried up as a result of the decline in the expected incomes from fishing, the populations of fishing communities continue to grow. The result is a continuous reduction of the resource-man ratio and a decline in the standard of living. Yet, migration to the metropolitan areas is hardly a blessing for developing countries already facing considerable urban unemployment and inadequacy of social infrastructure to cope with rural-urban migration.

Since very little has been done in the past to develop the fishing communities (e.g. supply the necessary infrastructure, promote new activities) except for some strictly fishing related assistance (e.g. motorization of canoes), it is very likely that there is considerable scope for such development. Promotion of tourism, handicraft, and coastal aquaculture are some obvious alternatives or supplements to fishing, but other activities presently located in urban areas may also be viable in the coastal areas if the necessary infrastructure was provided. In Trat, Thailand, for example, fishermen were reported to have received a dual benefit from the location of a fish processing plant in their province: (a) a higher price for their catch, and (b) additional employment opportunities for other family members.

The complementary relationship of fishing with non-fishing, land-based activities, has implications for development and management. The development of fishing communities need not be confined to the fish resource alone but can (and in many cases should) be integrated with these other activities. For example, while motorization of fishing boats may not be justified by the resource base alone, the opportunity to use the boats for transportation, trade or tourism when fishing is poor (e.g. monsoon season) may justify the investment. Care, however, needs to be taken to develop these alternative opportunities if viable but not available and at the same time to control effort in order to protect the resource from possible overfishing. Non-fishing activities also need to be taken into account when there is the risk that the contemplated fishery development would not enlarge the spectrum of opportunities available to the fishing community but just replace a viable non-fishing activity by additional fishing opportunities. For example, if when fishing is poor fishermen practice farming, the allocation of additional resources to a fishing community may be done at the expense of farming. In any case, in assessing the benefits of fisheries development projects, their impact on non-fishing activities, positive or negative, should also be considered.

The existence or lack of alternative employment has also implications for fisheries management. Control and reduction of fishing effort (including self-management) is easier and can be implemented more rapidly in fishing communities with a broad spectrum of alternatives. If non-fishing employment opportunities are not available but a resource base (land, location, forests, mineral resources, natural environment, etc.) for such activities exists, fishery management should go hand-in-hand with non-fishery development. Often there is also room for "non-fishing" fishery development, that is improvement of utilization, processing and marketing of catch which would create some economic surplus or at least improve the socio-economic conditions of fishermen and allow management schemes to be introduced. Enforcement costs are relatively low when alternatives to fishing exist and prohibitively high when fishing is the sole source of employment and income.

IV. LIKELY EFFECTS OF HUMAN INTERVENTIONS

4.1 Variations in Economic Parameters

Under constant economic and bio-ecological conditions an open-access fishery will reach an equilibrium at a level of effort and corresponding catch yielding zero profit to the fishery as a whole, although fishermen with lower cost may be earning some rents of efficiency. Since excess profits or losses is the moving force, their absence implies no changes in the level of effort and catch, that is, an equilibrium is established (see Figure 12).

Since the real world is not a static but a dynamic one, such equilibrium is more of a tendency than a reality. The costs of fishing inputs (fuel, nets, etc.) often have an upward trend while technical progress works so as to make the use of these inputs more efficient, driving the less efficient out when the resource limits are reached. On balance, costs may be rising or falling depending on the relative rates of increasing scarcity, inflation and technical progress. One would expect the change in input prices to be a smooth one while technical change brings about discrete changes in the efficiency of input use. However, since the energy crisis, fuel prices have escalated through discrete changes precluding a smooth adjustment process.

A rise in fishing cost would result in losses for the marginal fishing units forcing them to leave the industry. Thus, the number of fishing units and total effort expended by the fishery as a whole are expected to decline as a result of a rise in fishing costs 39/. Catch would fall in the short run. In the long run, catch would fall if the fishery is biologically underexploited (see Figure 14) and would rise if the fishery is biologically overexploited (see Figure 13). Reductions in fishing costs resulting from the introduction of a new fishing technology would have the reverse effects. However, no long-term benefit for the fishermen or the society results from technological upgrading under open-access conditions.

Changes in fish prices occur as a result of shifts in the supply of or demand for fish. With a given demand, a poor catch would lead to rise in price and a rich catch to a fall in price. With a given supply, rising demand (due to population growth or increasing incomes) would lead to rising fish prices. With unchanged costs, an increase in fish prices would result in excessive profits which would induce entry into the fishery and expansion of fishing effort until all profits are dissipated, and a new equilibrium is attained at higher effort (see Figure 15). Catch rises in the short run but falls in the long run if the fishery is biologically overexploited. Daily or seasonal fluctuations or prices may or may not affect the equilibrium level of effort depending on the ease of exit and re-entry (including the availability of alternative employment for labour and capital).

The effect of changes in mesh size or other regulations which improve the productivity of the resources and, thus, the total yield and, immediately, the individual catch rate, without affecting the fishing costs will be identical. On the long run, mesh size regulation will not improve individual incomes and the total economic rent, unless action is similarly taken to prevent the fishery to drift to a new equilibrium at higher effort. Therefore, mesh size and other gear selectivity regulations cannot be considered as an alternative to the regulation of the amount of fishing.

In small-scale multispecies fisheries the effects of changes in prices and costs are not likely to be as clear-cut. First, owing to the already noted fundamental asymmetry between entry and exit (the latter being often more difficulty than the former), favourable changes in costs or prices followed by unfavourable changes result in surplus numbers of fishermen earning incomes below their opportunity costs. By definition, lack of mobility is inability to respond to changes in economic conditions. If mobility towards the fishery is greater than mobility out of the fishery, favourable changes can hurt them. Second, in multispecies fisheries, changes in fishing effort resulting from a change in economic parameters may not result necessarily or only in the expected change in the quantity of catch but to a change in its composition. If the fishery supplies a large share of the market, the change in catch composition would cause a second-stage change in fish prices mitigating the effect of the original

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39/ This result, of course, depends on the objectives and motivations of the fishermen (see Section 2.3). If the fishermen do not maximize net income but they strive to attain a given level of net income, increases in costs or reductions in fish prices or catch may result in an increase in effort at least temporarily until the fishermen are forced by the new realities to modify downwards their expectations.

change. A fall in costs or a rise in price may make profitable (and even socially desirable) the "extinction" of some species. 40/

The most significant policy implication of this section is that, in the absence of restrictions on entry, reductions in the prices of fishing inputs, technological upgrading, and increase in the price of fish can benefit the fishermen only temporarily. In the long-run the fishermen cannot expect to earn more than their opportunity costs. In fact, an initially beneficial change (fall in costs, rise in fish prices) may ultimately hurt the fishermen if it encourages 'excessive' numbers of entrants who, once in the fishery, find it difficult to leave despite possible losses (see Table 2).

Similarly, an expansion in the resource base through manipulation of mesh size, type of gear and geographical distribution of fishing operations or simply through the allocation of more resources to the fishery, would lead to expansion in fishing effort and would have no lasting effects on fishermen's incomes as long as the open-access status of the resource remains unchanged. An expansion of the resource base is, thus, analogous to a rise in the price of fish and can be similarly represented diagrammatically as an upward shift of the total revenue curve (see Figure 15). In the absence of regulations of fishing effort, improvement in the utilization of catch, or the efficiency of the market system would have analogous effects: a temporary rise in incomes followed by expansion of effort and return to the previous income levels which, in the long-run, are uniquely determined by opportunity costs. The only way in which a lasting increase in fishing incomes can be effected is either by limiting effort through fisheries management or by raising the fishermen's opportunity cost through non-fishery development (creation of alternative employment). Fishery development can help only if it is implemented after or concurrently with fisheries management.

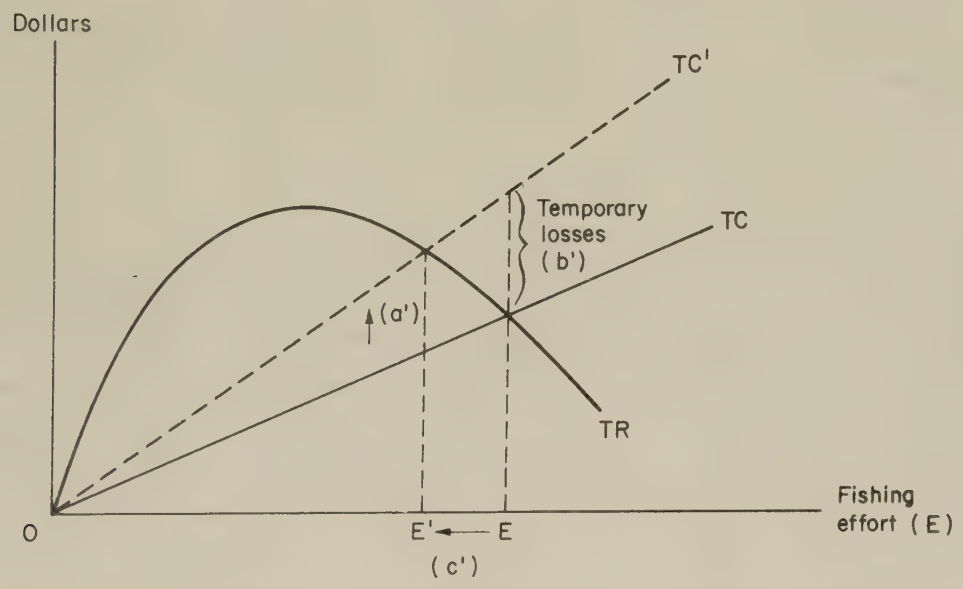

Figure 13 The effects of a rise in fishing costs in a biologically overexploited fishery: a rise in cost (a') -- temporary losses (b') -- exit (c') until a new open-access equilibrium (TR = TC) is established; no long-term effects on fishermen's incomes or on economic profits, but a rise in catch.

40/ Biological extinction of species is physically difficult and economically unprofitable. However, economic extinction in the sense of near disappearance of a certain species from the catch is not uncommon in multispecies fisheries.

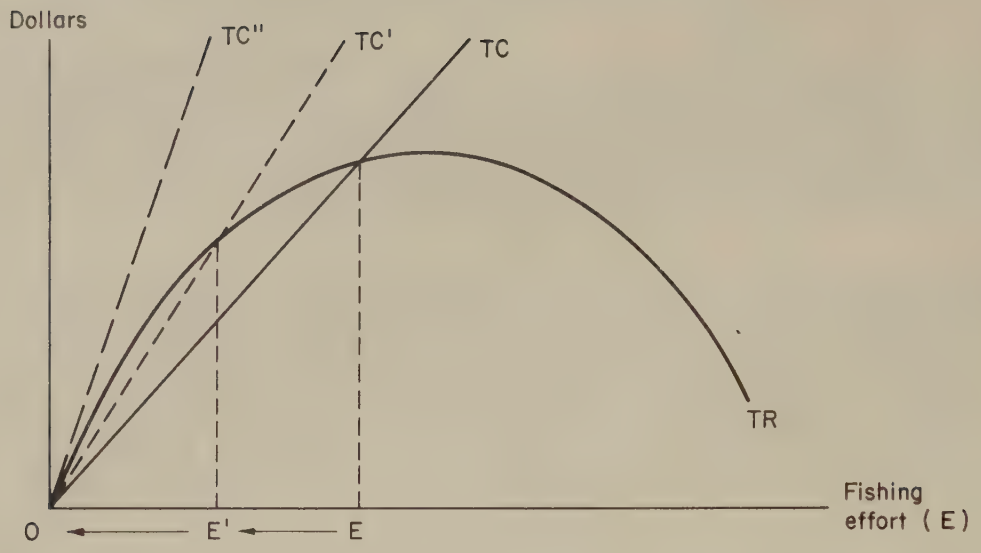

Figure 14 The effects of a rise in fishing costs in a biologically underexploited fishery: same as Fig. 13 except that catch falls. Fishing costs may rise to the point where the fishery becomes unprofitable and effort and catch are reduced to zero. This may even happen in a biologically overexploited fishery if the costs rise sufficiently.

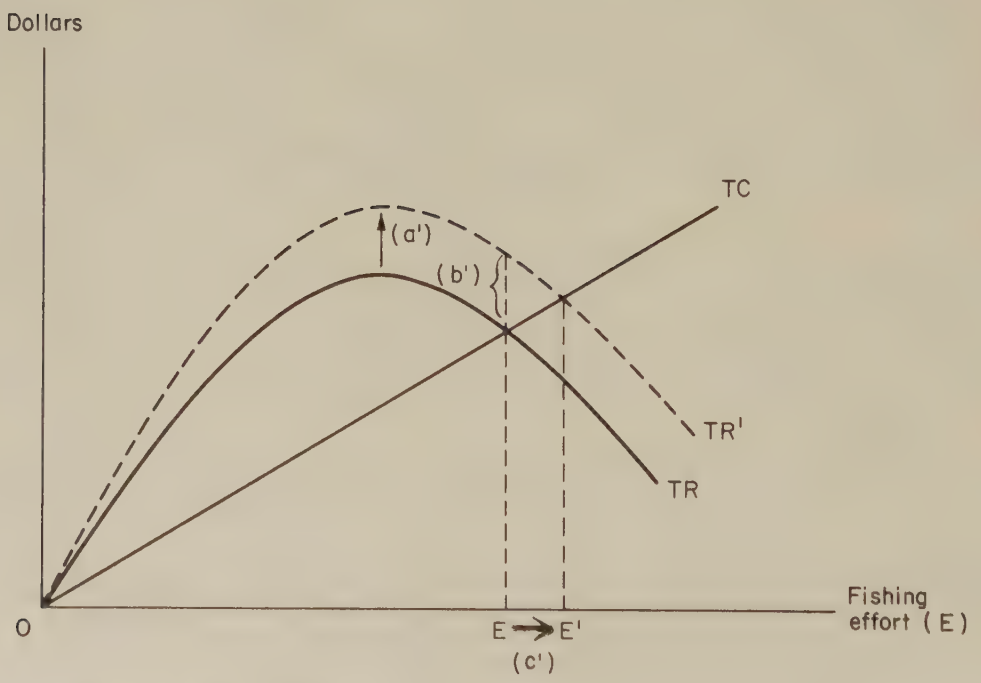

Figure 15 Effects of rise in the price of fish. Rise in price (a') -- temporary profit (b') -- entry (c') until a new open-access equilibrium (TR' = TC) is established. No long-term effects on fishermen's income. Economic surplus continues to be zero. If too many new fishermen are attracted into the fishery by the temporary profit, existing fishermen may incur losses if they happen to be less efficient and more immobile than the new entrants.

Table 2 Development and management of small-scale fisheries: Constraints, objectives and outcomes (A preliminary qualitative assessment)

TYPE OF INTERVENTION		Cost of Intervention: Implementary enforcement			CONSTRAINTS										OBJECTIVES AND OUTCOMES: Resource Constraint Binding									Resource Constraint Not Binding						
Development	Management	Economic	Political	Fishermen's objection	Limited fishing range	Multi-species short life span	Open-access resources	Scattered multi-gear	Conflicts with other fisheries	Distorted capital market	Low educational skill	Low mobility	Surplus labour/Lack of alternative employment	Protein supply	Employment	Income	Social effects	Integration	Gross economic surplus	Net economic surplus	Average fishing cost	Innovation	Food supply / Exports	Employment (FE) (UN)	Income	Social effects	Integration	Gross economic surplus	Net economic surplus
1. Fish subsidy	No management	H	L	L		X	X							♀-	?	♀	0	-	0	-	n/a		+	0 +	+	0	-	♀	?
2. Fuel subsidy	No management	H	M	L	X		X	X						♀-	?	♀	0	-	0	-	n/a		+	0 +	+	0	-	♀	?
3. Motorization	No management	H	L	L			X	X	X		X			♀-	?	♀	?	?	0	-	n/a		+	0 +	+	0	?	♀	?
4. Credit	No management	H	L	L	?		X	X			X			?	?	♀	0	?	0	-	n/a		?	0 ?	+	0	?	?	?
5. Marketing/ Infrastructure	No management	M/H	M/L	L			X	X						♀-	?	♀	0	+	0	(-)	n/a		+	0 +	+	0	+	♀	?
6. Post-harvest technology	No management	M	L	L		X	X							(+)	?	♀	0	0	0	(-)	n/a		+	0 +	+	0	-	♀	?
7. Promotion of cooperatives	No management	?	M	M			X	X			X			?	?	♀	?	?	0	-	n/a		?	0 ?	?	0	?	?	?
8. Resource allocation	No management	?	M	L	X		X		X	X		X		?	?	♀	♀	?	0	0	n/a		?	0 ?	?	0	?	?	?
9. Relation	No management	H	H	H			?	X			X	X	X	(+)	(+)	(+)	♀-	+	0	-	n/a		+	0	(-)	-	+	?	?
10. Alternative/ Suppl.employment	No management	H	M	L			?	X			X	X		(+)	(+)	+	+	+	0	-	n/a		-	0 +	+	0	+	?	?
1. Fish subsidy	"Limited entry" (Regulation of effective fishing effort)	H												0	0	+	← or →		+	0	n/a		+	0 +	+	← or →		+	?
2. Fuel subsidy	"	M												0	-	+			+	0	n/a		+	0 +	+			+	?
3. Motorization	"	M-H												0	-	?			?	?	n/a		+	0 +	+			+	+
4. Credit	"	M												?	?	(+)			(+)	(+)	n/a		(+)	0 (+)	(+)			(+)	(+)
5. Marketing/ Infrastructure	"	M/H												0	?	+			+	+	n/a		+	0 +	+			+	+
6. Post-harvest technology	"	M												0	?	+			+	+	n/a		+	0 +	+			+	+
7. Promotion of cooperatives	"	?												0	?	?			?	?	n/a		?	0 ?	?			+	+
8. Resource allocation	"	?												+	+	+			+	?	n/a		?	0 ?	?			?	?
9. Relocation	"	H												-	?	+/?			+	?	n/a		-	0 -	(-)			(-)	(-)
10. Alternative/ Suppl.employment	"	H												-	+	+			+	+	n/a		-	0 +	+			+	+
1. No development	Catch quotas	M	L	M		X	X	X	X	X				♀+	-	-	(-)	?	0	-	+	+							
2. No development	Area/seasonal clos.	M	L	M	X	X	X	X	X			X	X	♀+	♀?	♀	(-)	?	0	-	+	+							
3. No development	Gear regulation	H	M	M	X	X	X	X	X				X	♀+	♀?	♀	?	?	0	-	+	-							
4. No development	Mesh size regulation	H	L	M	X	X	X	X	X					♀+	?	♀	?	?	0	-	?	?							
5. No development	Trawl ban	H	H	L/H	X	X	X	X	X			X	?	♀?	?	♀/♀	♀/♀	-	♀0	-	(+)	0							
6. No development	Limit No.of boats	M-H	H	(H)			X	X	?			X	X	♀?	?	♀-	-	?	♀0	-	+	+							
7. No development	Taxes on effort/catch	H	H	H				X			X	X	X	♀+	♀?	♀?	-	?	+	(+)	-	+							
8. No development	Licences (free)	H	M	L				X			(X)	(X)	(X)	+	+	+	+	♀+	0	-	0	+							
9. No development	Auction of property rights	L	H	H				?	X	X	X	X	X	+	(-)	0/-	-	?	+	+	-	+							
10. No development	Community rights	L	M	L					X				?	+	(+)	+	+	?	(+)	(+)	-	(+)							

LEGEND:

- + Long-term increase
- ♀ Short-term increase
- - Long-term decrease
- ♀ Short-term decrease
- 0 Zero effect
- ? Ambiguous effect
- ( ) Effect possible but not certain
- X Binding constraint
- H High
- M Moderate
- L Low
- FE Full employment
- UN Unemployment

4.2 Assistance Programmes

The need for government assistance to small-scale fishermen may arise in at least three cases: First, when the fishery is, for some reason, economically underexploited, the government may attempt to correct possible market failures and relax binding constraints which hinder the further development of the fishery through development assistance (motorization of boats, introduction of innovations, subsidies, etc.). Second, when fishermen earn less than their opportunity costs the government may attempt to identify the cause of geographical or occupational immobility and provide retraining and relocation assistance. Third, when fishermen's (and others') opportunity cost is unacceptably low (e.g., below the government poverty line or low by comparison to other occupational groups), the government may attempt to uplift their socio-economic conditions through development or welfare assistance.

Basically, the government assistance to small-scale fishermen may be classified into two broad categories: (a) assistance which aims at correcting or mitigating the effects of market imperfections or removing impediments to growth and, hence, increasing the efficiency of the fishery and of the overall economy, and (b) assistance which aims at redistributing income from other socio-economic groups to the small-scale fishermen and, hence, at reducing socio-economic disparities. While distributional improvements may result from improvement in efficiency, they should be kept separate from deliberate distributional objectives accomplished at the sacrifice of efficiency. In the first category we may include the provision of infrastructure, the improvement of fish utilization and marketing efficiency, research and extension, promotion of fisheries associations, correction of relative price distortions, etc., while in the second category we may include the allocation of additional fish resources 41/.

Subsidies of any sort (on fish, fuel, boat engines, etc.) as well as credit and induced motorization, often aim at both efficiency and distribution but rarely accomplish either, partly because of open-access and partly because of the distortions which they introduce in the market mechanism. For a given rise in fishermen's income to be maintained, the amount of subsidy should be continuously rising to just cancel out the induced expansion in effort, obviously a self-defeating policy since the faster subsidies rise the faster effort would expand. The distributive objective of subsidies can be accomplished more permanently and with far lower costs through direct welfare transfers to "existing" fishermen. At least, in this case, it is not difficult to anticipate that many non-fishermen would try to qualify as fishermen.

A number of criteria should be employed in selecting an appropriate form of development assistance: (1) it should help not hurt the fishermen; (2) it should focus on factors of production which cannot be provided by the fishermen themselves; (3) it should be such that the fishery can eventually outgrow the need for it; (4) it should rank high in terms of cost-effectiveness; and (5) it should introduce no more than the absolute minimum of distortion in the market mechanism. Below we discuss briefly these criteria in the above order.

The first criterion, that any provided development assistance should help not hurt the fishermen, is not as trival as it might sound. It presumes anticipation of both the temporary and long-term effects of intervention. For example, motorization of canoes in an overexploited fishery, without additional allocation of resources may eventually make the fishermen worse off by increasing their dependence on purchased inputs whose prices are beyond their control. For example, there is some evidence that in parts of the Philippines, well-meant credit assistance for mechanization has helped the fishermen only temporarily; in the long term, motorized fishing units became increasingly unprofitable with the escalation of fuel prices. A recent study found that owners of small-scale motorized boats had an average income of US$ 362 compared to US$ 520 by a non-motorized boat (Librero et al., 1982). A similar situation is found in Malaysia where the early success of mechanization has turned into a liability with many motorized boats earning incomes below their opportunity coasts (Fredericks et al., 1982). Similarly, in an open-access fishery characterized by immobility, subsidies of fish prices or of input costs may lead to temporary profitability, excessive entry and a long-term reduction in fishing incomes of existing fishermen below their pre-intervention levels.

41/ Unless the additional resources can be exploited more efficiently (from the society's point of view) by labour-intensive artisanal fisheries rather than by capital intensive large-scale fisheries, in which case efficiency calls for the reallocation of resources.

The second criterion for the selection of the appropriate form of intervention is that development assistance should focus on factors of production which cannot be provided or procured by the fishermen themselves either because of economies of scale in their provision or because of their sheer cost relative to the fishermen's income. For example, the provision of infrastructure such as landing facilities, roads and market outlays is in the public domain; no fisherman should be expected to provide these facilities on his own and even if he could, they still should be provided by the state because of the tremendous economies of scale in their provision and their "public good" 42/ nature. At the other extreme, there are factors of production such as fuel, ice and nets which are private goods and should be the responsibility of the fisherman himself. In-between, there are the capital inputs such as boat and engine, whose costs are high compared to the fishermen's incomes and limited assistance may be justified, especially if the capital market is not properly functioning. The problem with motorization subsidies, like any other subsidies, is that it is easy to introduce them and very difficult to withdraw them. For example, in Sri Lanka the import and distribution of motorized boats at subsidized prices may have been justified in the 1960s and the early 1970s, but not today. Not only because of the cost of imported fuel, but also because the fishery is quite profitable (see Fernando et al.) and fishermen could save to purchase or replace their own boats. In fact, part of the fishery subsidies "could" be replaced by taxes to capture (a part of) the generated resource rents in order: (a) to regulate entry, and (b) to provide development assistance to the less developed sections of the fishery, to the extent that the resource constraint permits. It is recognized, however, that removing subsidies and introducing taxes is politically very difficult, if not impossible. Hence, subsidies introduce a more or less permanent burden for the society which should be recognized before their introduction.

Hence, a third important consideration in contemplating development assistance is the potential of the fishery to outgrow the need for assistance and the ability of the state to withdraw it when it is judged that it does no longer serve its purpose. Subsidies are notoriously difficult to outgrow because their recipients become accustomed to them and unprepared to face the market forces. In the case of fishing, subsidies encourage entry over and above the open-access level, and their removal would necessitate considerable reduction of effort and employment which may not be politically acceptable.

A fourth criterion for the selection of appropriate development assistance is that between a number of alternatives the one with the highest cost-effectiveness should be selected, that is, the assistance scheme which attains a given objective or set of objectives with the least cost. For example, if adoption of a new technology (e.g., boat engines, nylon nets) is profitable but fishermen are not adopting it for lack of knowledge of its existence or lack of confidence in its profitability, the most cost-effective form of assistance is not handing out the technology free of charge to the fishermen but providing them with the appropriate information and extension. Similarly, if fish prices are relatively low because of inappropriate fish utilization or high marketing margins, the most cost-effective assistance is not a price support scheme or a fish price subsidy but improvement of fish utilization and of marketing efficiency.

A related criterion is that intervention should aim at the "maximum" possible assistance to fishermen with the minimum distortion of the market mechanism. For example, instead of providing subsidized credit or subsidized boat engines, it might be more appropriate to remove the distortions in the capital market (such as implicit subsidies to large-scale fishermen) which result in unfair competition between small- and large-scale fishermen. Only after the distorted relative prices of capital and labour are corrected to reflect their true scarcities (capital scarce, labour abundant), can the problems of small-scale fishermen be seen in the right perspective. Under the prevailing policies of under-priced capital and over-priced labour, small-scale fishermen with no collateral and hardly any skill, besides fishing, have little access to (capital and hence to) fishery resources and no access to employment outside the fishery. Enabling small-scale fishermen to borrow at the same capital markets as large-scale fishermen, but with repayment schedules and administrative details they can

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42/ A public good is characterized by jointness in supply in that to produce the good for one consumer it is necessary to produce it for all consumers. The consumption of a public good, unlike that of a private good, by an individual does not diminish its availability to others. Although the production of a public good involves an opportunity cost, in terms of foregone quantities of private and other public goods, its consumption (short of over-crowding) involves zero opportunity cost. For more details on this and other market failures, see Panayotou, 1982.

meet, and allocating to them additional fish resources under limited entry conditions 43/ would do more for their standard of living than all conceivable subsidies under open-access conditions.

When all the aforementioned criteria for selecting forms of development assistance are brought to bear, it becomes obvious that the state should not intervene directly with fishing operations through input subsidies, fish price support or induced motorization schemes. Given the constraints (fluid and scattered fisheries, limited resource, open access, conflicts with large-scale fisheries and limited mobility), any such interventions are likely to: (a) prove very costly and difficult to withdraw; (b) hurt, rather than help, the fishermen in the long-run; (c) lead to further distortions of the markets and depletion of the resources; and (d) leave the society with a larger problem in the future and with fewer resources and ability to deal with it. Instead, development assistance should concentrate on creating an appropriate environment in which small-scale fishermen can operate in more even competition with each other and with large-scale fishermen.

If there is still unexploited potential in the fishery which fall outside the fishing range of small-scale fishermen, development assistance may take the form of gradual motorization of boats or of selective input subsidies if the market fails to achieve the desirable outcome and the government cannot improve the working of the market. Yet, the social benefit from such direct intervention should cover fully the social cost involved. If, however, the fishery potential is already fully exploited, development assistance should take the form of creation of alternative employment opportunities. As we have seen in the previous section, in the absence of restrictions on entry, fishing-related assistance to fishermen operating in a fully- (or over-) exploited fishery is self-defeating in the long run. In the short run, however, when no alternatives are available, there may be some justification in basing stop-gap or relief measures on the fishery. It might be 'optimal' to over-exploit the fishery to buy time for the development of alternatives outside the fishery 44/. Such short-term actions, however, should be planned with a long-term perspective. Moreover, for development assistance to have more than temporary impact, it should be accompanied by effectively enforced fishery management.

Without some regulation of effort, fisheries-related assistance sooner or later would be proved futile, as far as the socio-economic conditions of the fishermen and the society's long-term interests are concerned. As shown in Table 2, when the resource constraint is binding, there would be only a temporary increase and a long-term decrease in catch, and a temporary increase in fishing incomes at the expense of a permanent reduction in the fishery's net economic surplus (already zero before the intervention). The effect on employment is ambiguous since any gains in primary employment arising from the expansion of effort should be balanced against reductions of secondary employment arising from the reduction in catch. Under open-access and a binding resource constraint, only creation of alternative employment would have any long-term effects. If the resource constraint is not binding, fishery development assistance in the form of either subsidies or infrastructure may result in long-term increases in catch and employment, but not in income or in economic surplus whose changes are either temporary or ambiguous. As it can be seen from Table 2, fisheries development assistance has lasting effects only when fishing effort is regulated, particularly if, at the same time, the resource constraint is not binding. Although under these conditions both direct intervention through subsidies and indirect intervention through creation of condusive environment (infrastructure, improved catch utilization, more efficient marketing, etc.) work, the criteria of "cost-effectiveness", "easy withdrawal" and "minimum distortion" favour the latter. Improvement of the environment in which small-scale fisheries operate is effective even if the resource constraint is binding, provided effort is controlled. However, in the presence of terminal resource limitations and surplus labour in fishing communities, creation of supplementary or alternative employment (or gradual relocation in the absence of such prospects) is a sine quo non condition for upgrading small-scale fisheries and uplifting depressed fishing communities.

43/ "Limited entry" refers to effective limits on fishing effort and, thus, it applies to both labour and capital, in all their possible combinations and configurations. It is by no means sufficient to control only the number of fishermen or the number of fishing boats.

44/ However, this might be a very costly way of buyng time if it leads to an irreversible situation such as the collapse of certain high-value species, a not-unlikely possibility in the case of multi-species fisheries (see Chapter II).

4.3 Management regulations

As we have already seen, open-access leads to excess effort, possible biological overfishing and dissipation of all economic surplus that a fishery is capable of generating. Furthermore, the asymmetry between mobility in and mobility out of the fishery leads to depressed socio-economic conditions for fishermen and negative economic surplus for the society as a whole. Under open-access any attempts to further develop a fishery or simply to assist small-scale fishermen may be ineffective in the long-term because they attract additional effort which can nullify any short-term positive results that the intervention might accomplish. This is true whether resource constraints are binding or not; even if there is potential for further development and expansion once assistance is provided it would be only a matter of time before its effect on fishermen's income and economic surplus disappears under excessive effort.

Without some form of control on fishing, these and other similar objectives of fishery management such as improvements in the productivity of the stocks and reduction in the wasteful use of scarce resources whether natural or man-made, cannot be accomplished. Not even the objective of maintaining high employment may be realized in the absence of control on fishing since possible biological overfishing results in reduced sustainable catch and hence lower secondary employment in fish processing, marketing, etc. 45/ Neither is social friction avoided under open-access conditions for small-scale fishermen barely eke out a subsistence and they are in constant conflict with the large-scale fishery.

In Chapter II we have seen that there are two parameters which the fishery administrator can manipulate directly or indirectly to achieve the objectives of fisheries management: (i) the age or size of fish at first capture, and (ii) the total amount of fishing effort. By changing the size of fish at first capture, it is possible to increase the productivity of the stock and the net economic yield for a given amount of fishing effort, while changing fishing effort could have a similar result for a given size at first capture. Correspondingly, management regulations may be classified into: (i) regulations such as gear selectivity and seasonal, and area closures which aim at affecting the size and age of fish caught, and (ii) regulations such as catching capacity controls and catch quotas which aim at affecting the amount of total effort or the quantity of the catch. A third type of management scheme (territorial rights) aims at creating a conducive environment of self-control by the fishermen themselves instead of attempting to control fishing directly.

The choice among these management alternatives would depend largely on the specific features and circumstances of the fishery concerned and the objectives of the management authority. yet, this choice should be based on a set of criteria which include: acceptance by the fishermen, gradual implementation, flexibility, encouragement of efficiency and innovation, full cognizance of regulation and enforcement costs, and due attention to employment and distributional implications.

Firstly, for a management regulation to have a fair chance of success at economically justifiable enforcement cost and a politically acceptable degree of coercion, it must have the support of the majority of the fishermen. This is especially important in small-scale fisheries where enforcement is complicated by the dispersion and fluidity of fishing units. On the other hand, it is a fairly restrictive criterion since fishermen are not likely to agree to any regulation which would deprive them from access to the fishery or in any way threaten their absolute or relative position in the fishery, unless appreciably superior alternatives are proposed. Even then, social factors and other causes of mobility may prompt them to oppose regulations which they see as a threat to their traditional way of life and source of livelihood. Hence, a second criterion for the selection of an appropriate management regulation is that it should be amenable to gradual implementation. For example, the auctioning of fishing rights is likely to exclude, right from the start, many small-scale fishermen with no alternative employment.

A third criterion is that an appropriate management regulation should be sufficiently flexible to allow for adjustment to changes in economic and biological conditions. Tropical pelagic stocks, for example, are subject to unpredictable fluctuations. Flexibility in multispecies fisheries is particularly important because of our limited knowledge of species interactions and of the reactions of stock composition to changes in effort. In recent years, economic conditions (e.g. fuel costs, fish prices and

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45/ M. Ben-Yami has pointed out to me the possibility of some additional secondary employment being generated by overfishing because of the greater processing requirements of smaller species compared to prime fish (whose share in the catch is being reduced by overfishing).

fish technology) have been changing rapidly. Management regulations such as catch quotas which do not allow the necessary flexibility for adjustment to changing conditions or imply heavy research costs to monitor stock fluctuations may lead to serious overfishing or at any rate operation at suboptimal levels for part of the time depending on the frequency and magnitude of these changes.

A fourth criterion is that a proper regulation should encourage the fishery to operate at the minimum average cost, and provide incentives (or, at least, leave scope) for improvements in efficiency through both tactical changes in the pattern of fishing and innovative changes in fishing technology. This is of utmost importance since higher efficiency means larger spread between the value of the catch and fishing costs and hence higher income for the fishermen and/or economic surplus for the society. Again, overall catch quotas fail this criterion since they induce a fierce competition among the fishermen to catch as much fish as possible before the quota is filled. Naturally, total fishing costs rise to the level of the value of the catch (hence zero economic surplus) as the fishing season is reduced to the absolute minimum for filling the quota. However, individual catch quotas, if enforceable, can eliminate excessive competition and enable individual fishermen to reduce their fishing costs down to the minimum required to secure their quotas.

A fifth criterion is that a proper management regulation should take full account of the research, enforcement and monitoring costs involved and political factors constraining its effective implementation. For example, mesh size regulation or taxes on effort may be very costly to implement in scattered multigear fishing units.

A last criterion is that an appropriate management regulation would take full cognizance of the employment and distributional implications and weigh them against the other objectives of fisheries management (improvement in fishing incomes, maximization of economic surplus, reduction of gear conflicts, etc.). For example, mesh size regulation and closure of nursery areas in shallow waters have implications for income distribution (and employment) because they affect disproportionately the inshore fishermen; in fact, they involve a net transfer of income from inshore small-scale fishermen to offshore industrial fisheries.

On the basis of these criteria and the constraints under which small-scale fisheries operate (discussed in Chapter III) we attempt an evaluation of the potential applicability and effectiveness of the following management alternatives: gear selectivity, gear restrictions, seasonal and area closures, catch quotas, fishing effort controls, economic controls (taxes, licence fees and price controls), and territorial rights (property rights over the stock or an area, leasehold arrangements, franchises and rights of use). The costs and effects of these management regulations are qualitatively discussed in the sequel and summarized in Table 2 (above).

Selectivity of gear such as restrictions on the size or spacing of meshes and hooks or the opening of pots aim at achieving and maintaining the most productive age structure of the stock by allowing immature fish to grow larger and more valuable and to possibly reproduce before they are caught. When different fishermen focus on different age or on different species (using the same type of gear), selectivity of gear has obvious distributional implications. In the case of an inshore small-scale fishery which focusses on young fish migrating offshore where they are exploited by a large-scale fishery gear, selectivity involves a reallocation of the resource in favour of the offshore fishery. As a result, the overall yield from the fishery would improve while the income and employment of small-scale fishermen would deteriorate 46/ with consequent social problems. The net economic surplus would remain zero (in fact, become negative by the amount of the cost of regulation) since any rents created in the offshore fishery 47/ following the regulation would attract new entrants to the point of complete rent dissipation. Moreover, with scattered and fluid, multi-gear, multi-species fisheries the enforcement is likely to be difficult and costly, especially since small-scale fishermen would certainly oppose such regulations. Thus, we may conclude that gear selectivity (despite its potential usefulness in improving resource productivity) might not do as much good as expected, without a prior effective control on effort and resolution of the fundamental allocation problem between artisanal and commercial fisheries. The importance of the control of effort to fully reap the gain in productivity to be accrued from regulations on gear selectivity cannot be over-emphasized, as no long-term improvement in individual incomes and economic surplus can be expected in the absence of effort regulation.

46/ Only few displaced small-scale fishermen can expect to be employed as crewmen in the offshore fishery because of its capital-and-skill intensity.

47/ Even short-term rents may not be created because of the higher costs of catching the fish once dispersed offshore.

Gear restrictions such as a ban on the use of poison and explosives aim at the protection of the resource and its productivity while others such as a ban on trawls, synthetic nets, and fish finders are introduced ostensibly to protect the resource from "destructive" gear but their true aim is to protect the position in the fishery of another less efficient gear for political or social reasons. Both restrictions have extreme distributional implications. The ban on poison and explosives, if effective, often involves a reallocation of the resource away from the poorest of the fishermen 48/ towards fishermen who can affort legitimate types of gear and towards future users of the resource. It could be rejected as counter-distributive unless assistance to acquire legitimate gear or alternative employment are provided to the displaced fishermen. Here too, no long-term improvement in incomes and economic surplus can be expected in the absence of limitations on entry of the legitimate types of gear.

The ban on trawls and other relatively efficient gear involves a reallocation in favour of the small-scale coastal fishermen, who may or may not employ less efficient types of gear. While temporarily the sacrifice of some efficiency in the name of a more equitable distribution might be acceptable, a complete ban on trawlers is likely to be an unnecessarily large sacrifice when many of the trawling grounds are not accessible to small-scale fishermen. Most likely, the harmful effects of trawlers on the resource and on coastal fishermen could be minimized through gear selectivity and area allocation between the two fisheries. Following the banning of truly destructive gear, the yield would increase, employment would fall for those using the banned gear and would rise for the rest, but no long-term improvement in fishing incomes or net economic surplus can be expected without effective control of entry. A total ban is easy to enforce but it may have adverse effects on efficiency and innovation.

In this context, the recent total ban on trawlers by Indonesia deserves some comment. In the words of the Director General of Indonesian Fisheries "As a culmination of trying to solve the problem of trawlers in Indonesia, in her continuous effort to protect the poor traditional fishermen masses, on 1 July 1980 the Government reached the political decision to ban the operation of trawlers in Indonesia gradually by Presidential Decree No. 39 of the year 1980" (Sardjono, 1980). Was this trawl ban the most appropriate management tool under the circumstances? The Indonesian trawl ban came in a background of violent clashes between traditional fishermen and trawlers, and after several arrests and demonstrations; earlier regulations limiting the number of licensed vessels and their area of operation proved "ineffective" in keeping illegal trawlers off the coastal waters. Considering the intensity of the conflict, the government's difficulties in enforcing other more complex regulations 49/, and the predominance (95 percent) of small-scale fishermen in the Indonesian fishery the total ban on trawlers does not seem unreasonable under the circumstances. In the government's estimate, catch is expected to fall temporarily by 10 percent and be made up soon through the conversion of trawlers into other types of gear and the expansion of the small-scale fishery with government assistance through credit and extension services. Yet, efficiency and innovation are certain to suffer as a result of the ban and part of the offshore demersal resources is likely to remain underexploited, 50/ or be harvested by foreign fleets. In socio-economic terms, the trawl ban is likely

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48/ It is not suggested here that the poison and explosives are used only by the poor fishermen but that they would be the ones most affected by the ban since they cannot affort legitimate types of gear. On the degree of destructiveness of poison and explosives there are opposing views apparently referring to different types of fisheries. M. Ben-Yami (pers. comm.) argues that, with the exception of coral reefs, poison and explosives have rather limited effect on stocks and environment: "the main danger of using dynamite is that fishermen lose their hands or fingers". On the other hand, Bardach (1976:18-19) quotes Tugnola Efi, Prime Minister of Samoa: "Fish inside the reef which were once the mainstay of our protein diet are becoming increasingly scarce. Ava niu kini and dynamite are largely responsible. I have witnessed the trauma of the deathly white and soften coral and sea plans a day after laying of the ava niu kini. There is an eeriness which bespeaks mutilation profanity and even death. As fish become scarce, the ava niu kini and dynamite ... seem to the fishermen even more necessary to ensure a respectable catch. That catch does not suffice, use of dynamite notwithstanding ..."

49/ Of course, the savings in enforcement costs through the total trawl ban must be balanced against the losses in fishing efficiency.

50/ C.H. Newton has commented that this may not matter much if the objective of the government is to satisfy small-scale fishermen and consumers with supply of juvenile species at low costs. By banning trawlers in the Java Sea, the prices for adult demersal species will increase and thereby make fishing for such species viable in the Arafura Sea.

to result in a temporary increase in the incomes of small-scale fishermen and a gain in fishing employment which will expand to bring the fishery to a new bio-economic equilibrium where small-scale fishermen earn no more than their opportunity costs. That is, without some form of control on the number of small-scale fishermen themselves not even a total ban on trawlers is likely to produce a lasting improvement in their incomes; unless the elimination of coastal encroachment by trawlers encourages the revival of traditional forms of self-management.

Seasonal and area closures aim at improving the productivity of the resource by ensuring uninterrupted spawning and protection of juvenile fish. The closure of a fishery during certain seasons or in certain area may also aim at controlling total effort and catch. The first objective is easily accomplished if spawning and nursery areas and seasons can be accurately determined. This might be difficult as these areas and seasons often change from year to year. The closure to fishing of a well-defined area such as a bay, an estuary or a lagoon or the closure of the entire fishery for a certain season can be relatively easily enforced. In contrast, the closure of a large offshore areas or the closure of the fishery for small and frequent time intervals or for only some species involves considerably higher monitoring and enforcement costs. Since spawning and nursery areas of many species are located along the coast (bays, estuaries, lagoons, etc.), the area and season closures affect disproportionately the small-scale fishermen who operate almost exclusively in coastal areas. Unlike the mobile and resilient large-scale fishery, small-scale fishermen cannot take up offshore fishing during the closed season or shift to other fishing grounds following a closure of their traditional fishing grounds. Although potentially useful for raising overall yields, area and season closures tend to reallocate the resource in favour of the offshore fishery 51/, thus idling and impoverishing small-scale fishermen, unless assistance is provided to facilitate their participation in offshore fishing. Closed areas, in particular, impose a burden on small-scale fishermen who do not have the mobility to fish other areas.

As a means of controlling total catch or effort, area and season closures are ineffective, encouraging wasteful expansion of effort as the fishermen attempt to make the best of the open areas and seasons. The adverse consequences of the increased fishing intensity in open areas or during open seasons and the resulting increase in overall fishing costs may more than offset any beneficial effects of the closures on the productivity of the stocks. Another type of area closure is the prohibition of certain types of gear (e.g., trawl) from operating in coastal areas reserved for small-scale fishermen. This has certain advantages over a total ban or a total area closure but it is also more difficult to enforce. Area (or resource) allocation is a useful management tool for resolving conflicts between mutually incompatible types of gear such as trawls and stationary gear, as well as for encouraging self-management (see territorial rights below). Creation of artificial reefs has been suggested as a physical mean to prevent trawling in inshore areas, while enhancing the fish productivity, e.g. through extensive aquaculture on man-made reefs.

Catch quotas aim at improving the productivity of the stocks through direct control of fishing mortality. Theoretically, any catch quota can be set and enforced thereby maintaining the stock at the desired level of production. However, the socio-economic consequences of an overall catch quota are highly negative. The fishing race continues unabated as fishermen have to expand their catching capacity to main or increase their share of the quota, with the ultimate result of an increase in fishing costs, a reduction in the duration of the fishing season and a complete dissipation of economic surplus regardless of the level of the quota. In multispecies fisheries, a total catch quota can be more harmful as the ensuing competition is likely to result in the catch being concentrated on the most valuable species with the risk of their progressive extinction. When both artisanal and commercial fishermen exploit the same stock, a total quota is certain to effect a reallocation of the resource in favour of the commercial fishermen who have greater catching capacity and ability to expand it further. Unavoidably, both income and employment of small-scale fishermen would be reduced while no economic surplus would be generated by the fishery as a whole.

51/ Of course, this is so only where the offshore and the small-scale fishermen share the same stocks or, at least, exploit interdependent stocks as is often the case with small-scale fishermen operting near the coast, in lagoons and river estuaries; they exploit the juvenile stages of the same stocks which large-scale fishermen exploit further offshore.

In order to eliminate this unfair and damaging competition, the management authority may attempt to divide the overall quota between groups of fishermen such as artisanal and commercial fishermen. These quotas may be divided further between fishing communities and even between individual fishermen to eliminate in-group competition and encourage the fishermen to minimize the cost of catching their share of the total quota. Despite their theoretical appeal, individual quotas are difficult to put into practice because of the natural fluctuations of the stocks, the fluidity of the catch, and the fluidity and dispersion of the fleet, especially of the small-scale fishing units. Monitoring the catches of large numbers of artisanal fishermen scattered in remote communities and enforcing individual quotas would be an extremely costly undertaking and an administrative nightmare especially in developing countries with poor communication networks and limited statistical systems. Furthermore, there is the difficult problem of devising a method for allocating individual quotas which would encourage efficiency without excluding the poorest of the fishermen who cannot compete for quotas in the market. Not only certain quotas may have to be allocated to them free of charge but also limits on the transferability of these quotas may have to be set in order to reserve a place for them in the fishery.

Fishing effort controls such as limits on the number of fishing units, on the quantity of gear, or on the catching capacity of vessels aim at improving the yield and economic performance of the fishery through a direct removal of excessive fishing effort. As we have seen in Chapter II, effective fishing effort (or fishing mortality) is the product of the number of fishing units, their fishing power, the efficiency with which catching power is used and the time spent fishing. Catching power, in turn, is determined by various characteristics of the fishing unit, such as the tonnage and horsepower of the vessel, the size and type of gear, the fish-finding technology, etc. To be effective, fishing effort controls must limit total effort, not just some of its components; otherwise, the fishermen will substitute the unrestricted components for the retricted ones, thus producing a higher effective effort at a relatively higher cost. Yet, limiting all the components of effort would not only be administratively cumbersome and costly, but it would also put an end to technological improvements and the ensuing gains in efficiency. A good management scheme should use, even encourage, the fisherman's technical and tactical 52/ attempts to increase his efficiency because they mean savings in scarce resources, reductions in fish prices and increases in economic surplus.

What the management should control is total effort, not how it is produced, unless social considerations dictate a temporary sacrifice of some efficiency to maintain employment or to improve the incomes of artisanal fishermen. Thus, an appropriate management plan would (1) determine the catching power of the various fishing units; (2) control, even imperfectly, their fishing power by limiting one or a few factors having a major effect on the catching power of the fishing units (e.g., the number and size of traps, the length of a purse seine, etc.); (3) license only a number corresponding to the "optimum" level of effort; (4) allow the licensed fishermen to make the adaptations and innovations they see fit; and (5) control overall effective effort at the predetermined level by withdrawing excess catching capacity resulting from the gains in efficiency. This, of course, raises an allocation problem of particular imnportance to small-scale fishermen, who would be allowed access to the fishery and how would subsequent reductions in excess capacity affect different groups of fishermen.

Auctioning or market sale of a limited number of licences is certain to exclude many small-scale fishermen who have poor access to funds to bid for or purchase a licence. Similarly, subsequent withdrawals of capacity may affect disproportionately the small-scale fishermen whose gains in efficiency are likely to be more limited than those of other participants. These problems can be resolved through a political decision to allocate a certain number of licences to small-scale fishermen and preventing transferability outside of the group. As the small-scale fishermen gain in efficiency and alternative employment opportunities are developed outside the fishery, both the number and the transferability of these special licences can be reduced. However, the dispersion, fluidity and remoteness of small-scale fisheries may reduce the effectiveness of the scheme in limiting entry; potential entrants failing to obtain a licence might engage in illegal fishing. Moreover, the use of many different types of gear, vessels, and methods of fishing by artisanal fishermen make comparisons of fishing power and hence management through control of effort more difficult and costly than would have been the case with a more homogeneous fleet.

52/ That is, the improvement of the distribution of his fishing operations, i.e. the use of his nominal fishing capacity, relatively to the time and space distribution of the most valuable species available to him.

Economic controls such as taxes on effort or catch, royalties and licence fees aim at indirectly controlling fishing effort by directly removing the economic surplus (or resource rent) which encourages over-expansion of effort in the first place. Taxes and fees drive a wedge between the social and private costs of fishing which dissuades fishermen from expanding effort beyond the socially optimum level. Although economic controls do not affect the long-term incomes of the fishermen, the temporary increase in costs which they entail makes them unacceptable to the fishermen. In developing countries with poorly functioning tax collection systems and with scattered small-scale fishermen barely earning subsistence incomes, taxes are out of the question for both economic and political reasons. With the variability in yield, prices and costs and heterogeneity of and dispersion of small-scale fisheries, it would be difficult to determine the correct level of the tax, and even more difficult to impose it and collect it 53/. On the other hand, royalties can be automatically determined and collected by auctioning fishing licences but such a system favours the more efficient operators with access to capital, to the exclusion of most artisanal fishermen. Moreover, taxes and fees on small-scale fishermen, who in many countries are at the bottom of the income scale, are counter-distributive as they transfer income from a low-income group to the average-income group (the society at large). We may conclude, thus, that despite their potential usefulness in extracting resource rents and controlling the expansion of effort in rapidly expanding and highly profitable fisheries, economic controls are not likely to be of much help in managing small-scale fisheries in developing countries.

Resource allocation through territorial rights, such as leasehold arrangements, franchises, or allocations of ownership over an area or a stock, aims at creating the appropriate environment for self-management through the establishment of private or community "ownership" over common property resources. The "owners" of the resource having an interest in its current and future productivity would be inclined to control fishing effort so as to maximize the net benefits from the resource, in much the same way as farmers regulate their farming activities to maximize the returns from their land. However, for such a system to be workable, those allocated rights to the resource should not only be in a position to deny access to others but they should also clearly perceive that their actions have a direct and pronounced effect on the state and productivity of their portion of the resource (and hence on their future profits). These conditions are certainly met in the case of sedentary or slightly mobile resources such as seaweed, oyster and clam beds and in the case of resources within well-defined geographical areas such as tidal lands, swamps, self-contained bays, lagoons and river estuaries. Even with more mobile resources, like crustaceans, and open areas, like coastal waters, there is a possibility of dividing up the resource as long as the fish displacements and migrations between portions are not sufficient to obscure the connection between the "owner's" current actions and his future profits. There are several examples of territorial rights in traditional fisheries ranging from lagoon fishing in Ivory Coast through river estuary fishing in Brazil to coastal fisheries in Sri Lanka and Japan. In fact, community fishing rights and other forms of proprietary rights have been the rule rather than the exception in many traditional coastal fisheries (Forman, 1970; Cordell, 1974 and 1981; Johannes, 1976; Klee, 1972 and others) until fairly recently when they began breaking down under the pressures of population growth, advanced fishing technologies and the general, official adoption of the common property and open-access concept.

The revival and rejuvenation of traditional community rights over coastal resources offer, perhaps, the best possible management option for scattered, remote and fluid, small-scale fisheries.

53/ F.T.Christy has brought to my attention at least two instances in which some forms of taxes are in effect. One is in the Maldives where exported fish are subject to a dual exchange rate system that has the effect of a tax. Tunas and a few other fish can only be exported through a government agency. The agency sells the fish at the open rate of exchange but buys fish from the fishermen at an administrative rate of exchange which is about half the open rate. Thus, revenues are extracted by the Government from the fishing operation and used to subsidize the import and sale of certain staple commodities. The other is the People's Democratic Republic of Yemen where prices for fish are controlled as a means for providing low-cost protein to consumers. This also operates as a form of tax, discouraging excess entry into the fishery and creating economic rents in the form of the saving in food purchases received by consumers.In addition, there are certain instances where economic rents are taken in the form of propitiatory payments for religious purposes or extracted illegally in the form of bribes.

Such revival would necessitate a removal of the factors responsible for the breakdown of these traditional management systems by: (a) explicitly allocating the coastal resources to artisanal fisheries; (b) dividing these coastal resources among fishing communities; (c) regulating entry into and (d) gradually encouraging exit from the artisanal fishery by creating more attractive employment opportunities outside the fishery. Once encroachment of the coastal resources from the sea by commercial vessels and from the land by impoverished rural dwellers is effectively contained or is substantially reduced, the connection between the level of fishing effort expended by the community and its well-being would become apparent and self-regulation will be put into effect by the community leadership or through peer pressure. In the words of Emmerson (1980:32,42) "Social networks impose upon self-serving individuals a larger rationality of the whole, notably the community's interest in surviving physically, its institutions more or less intact, with some semblance of internal peace ... Where kin and neighbours seek a livelihood day after day from a (small and shallow) marine space, hunters are likely to share proprietary feelings about their obvious limited quarry ...". Community enforced management has the advantage of minimum monitoring and enforcements costs, although in certain cases (mobile or widely fluctuating stocks) the community would need scientific information and outside assistance in determining the appropriate fishing rate. The efficiency and distributional implications should also be made clear: by allocating a portion of the resource to a certain community, both more efficient operators and more disadvantaged potential entrants from outside the community are permanently denied access to the resources. These losses in efficiency and employment should be balanced against the benefit from a well-managed fishery and uplifted fishing communities at relatively low management and development costs.

4.4 Some examples of traditional territorial rights

Because of the potential which the revival of traditional property rights holds for small-scale fisheries management, we review briefly a number of such cases: (1) the "temporary territorial claims" system in an estuary canoe fishery in Brazil, (2) the Japanese "fishery right system" in coastal fisheries, (3) the Sri Lankan "access right system" in the beach seine fishery; and (4) "traditional fishing rights" in a lagoon fishery in the Ivory Coast.

Cordell (1980) decribes the establishment and evolution of a system of temporary territorial claims in Brazil. Canoe fishermen operating in a river estuary in Valenca, Eastern Brazil, succeeded through a rather complex system of zoning and timing based on the lunar-tide cycle to control internal population pressures and set limits on the intensity of fishing through access limitations which established fishing as a reliable long-term occupation. Although the resource moved with the tide, the fishermen were able to map out its distribution in time and space and establish "temporary territorial rights which (could be) converted into long-standing territorial claims". Competition between different fishing methods was eliminated through the zoning which had matched fishing methods and fishing grounds according to the effect of the tide cycle on their efficiency. This had a "boat-spacing" effect. Competition between the same type of gear was reduced through the selection of fishing spots (which had both a spatial and a temporal dimension) by individual captains on the basis of their knowledge of the tide movements and the fishing grounds. Although it was not unlikely for two or more captains to select the same fishing spot, the first to reach the spot had a temporary territorial claim while, in the absence of clear-cut prior claims, lots were drawn. What prevented a common-property-type of race for the premium fishing spots was a community ethic for captains to anticipate and avoid competitive encounters in deciding where to fish each day 54/. This resulted in a situation where a limited number of captains owned "chunks of the lunar-tide fishing space", exercised deliberate control over the "opportunity structure of fishing" and passed their skills to a limited number of apprentices. Thus, the fishermen on their own were able to stabilize their production system, set limits on the intensity of fishing and resolve inter-gear conflicts through a system of temporary territorial claims. To quote Cordell (1980:57):

54/ Forman (1970) refers to a similar system in raft fishing in Northeastern Brazil where, however, "secrecy regarding particular spots within the grounds serves as a spacing mechanism which minimizes competition and prevents overfishing by according temporary property rights to individual fishermen".

> "In planning their economic strategies as if there were always a potential overfishing situation, they had established temporary territorial claims which ensured that only gradual expansion of fishing operations took place. Thus, the opportunity structure of traditional fishing, and by extension the population as a whole, was able to grow at a resource harvest rate which was compatible with continuing availability within a fixed location. Trouble only came to canoe fishing when the previously adaptive ratio of production units to available water space was disrupted by the unregulated entry (emphasis mine) of a competitive group of nylon (net) fishing entrepreneurs."

The Japanese fishery right system 55/, as legalized by the Fishery Union Regulations of 1886 and systemized by the Fishery Law of 1901, established a fisheries management system which was a combination of both communal and private fishing rights. The community was granted exclusive property rights over the coastal grounds which were vested in a community fishery association or cooperative. All households wanting rights to fish were required to join the association whereby they automatically acquired a "title" to the coastal fishing grounds which bestowed the privilege to fish the communal waters. The role of the association was not to engage in fishing but to control the fishermen and be legally responsible for enforcing the rules and regulations pertaining to the communal fishing rights. The private fishing rights, on the other hand, "reserved specific areas within the coastal waters or a specific season of the year, for specified kinds of fishing with specified kinds of equipment" (Comitini, 1966:421). These private rights were granted to their traditional owners, the village bosses known as oyakata who, as owners of fishing assets, were the main employers in the community. The private-right fisheries pre-empted the more profitable grounds in the coastal areas and, with the introduction of advanced technology, they steadily increased their share to the detriment of the household operators of the communal-right fisheries. Although many were employed by the oyakata, a situation of surplus labour in fishing villages was eventually created which, in conjunction with the introduction of advanced technology, fuelled the development of the offshore and deep-sea fisheries which, in turn, led to overfishing and conflicts with the coastal fishermen. This led the fishery authorities to introduce restrictions on areas, seasons and gears which amounted to reserving a coastal strip for small-scale operations, and a second strip further offshore for medium-scale trawlers, as means of resolving these conflicts and securing the survival of small-scale, labour-intensive operations 56/.

Thus, on the one hand, the perpetuation of the fishery right system with its curious combination of communal and 'monopolistic' private property rights has forced independent operators into offshore fishing, thus relieving the pressure on coastal resources while, at the same time, it recognized, at least in principle, the right of every household to participate in the coastal fishery. On the other hand, the restriction of technology and the allocation of the resource between socio-economic groups amounted to subsidization of small-scale operators and resulted in maintenance of a high level of employment, averting the socially-disruptive displacement of surplus fishing labour. Comitini (1966:425) hypothesized that the goal of this apparently contradictory management system was "both to maximize employment for the large fishing population and to secure the maximum sustained yield from marine resources".

Sri Lankan coastal fisheries have a history of traditional property rights in the form of rights of access and closed communities. In earlier times, beach seine owners controlled the access to coastsl waters and had associated fishing rights which, along with other property, were subject to bilateral inheritance (by descent or marriage). Although, at the start, each beach seine owner had his own beach 57/ in which he had exclusive rights to operate, each of his children had only a fraction, not of his beach, but of his right to fish off the beach along with his brothers and brothers-in-law. While there was no limit on the number of nets that anyone holding rights to access could have constructed, the fishermen in a given beach, being a single kinship group, refrained from constructing additional

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55/ This section draws heavily on Comitini (1966).

56/ The number of large otter trawlers was progressively reduced and their size increased to encourage deep-sea fishing.

57/ The operation of a beach seine required an area of 6,000 square yards of sandy bottom. The first entrants had established property rights over the limited sites. These were passed on to their descendents, who thereby inherited a share in their father's net as well as the right to construct their own net for use on the beach.

nets unless they could bring in a catch whose value would have been higher than the cost of the net, that is they acted as a single economic unit. However, following successive inheritence and population growth, each group which had access rights to a beach has grown so large and remote in kinship that owning a net became gradually the means of exercising one's rights to the resource. Alexander (1980a:103), who studied the Mawelle beach seine fishery, illustrates convincingly this development which transformed the beach seine into common property:

> "If there were twenty nets, a man with one net would receive 1/20th of the annual catch. But after his death his two sons take joint ownership of his net, they each receive only 1/40th of the catch, whereas if one constructs a new net they each receive 1/21st. Thus, although the construction of new nets was clearly uneconomic from the viewpoint of the community as a whole, there were good reasons why individual fishermen, especially those from large families, should construct new nets. The optimum number of nets was reached before 1920 and the consequent increase involved additional investment for which the marginal product was zero."

Thus, the right of access system, while effective in blocking entry by outsiders, failed to limit the effort (number of nets) employed by the members of the community itself. Although the fishermen were aware that only a fraction of the existing number of nets would have obtained the same catch while generating substantial profits, they had no way of rationalizing their fishery. Instead, they accepted the ownership of nets as a distributional device and they attempted to give equal opportunities to all nets through a rotation system which enabled each net to be used in all locations and seasons every so many years. This meant equitable sharing of increasing poverty to the point that ownership of a share could not provide for subsistence. In response, the government introduced a licence scheme which limited the number of beach seines at each community to those existing in 1933, thus destroying the "rights of access" concept; new entrants could participate in the fishery only by buying shares in existing nets. While the legislation opens the door for the sale of shares to people without hereditary rights, it did not prevent the construction of new nets; predictably enough, most shares were accumulated in the hands of a small elite with access to capital which converted a subsistence technology into a profitable enterprise by limiting the number of nets. At present, beach seining, though outrun by modern gear, still remains profitable in some locations where it is controlled by one or two licensees who own the nets and employ crew on a wage basis (Alexander, 1980a).

In Sri Lanka, traditional property rights are not peculiar to the beach seine fishery. A recent study (Fernando et. al., 1982) found that Sri Lankan coastal fishing villages are generally "closed" communities in the sense that persons from outside the village are not allowed access to the fishing grounds of the community. Outsiders are not allowed to anchor or beach fishing boats along the shoreline of the community and labour is not recruited from outside the village. These restrictions on entry help to explain why Sri Lankan coastal fishermen, unlike many other small-scale fishermen in Asia, earn incomes appreciably above their opportunity costs. However, the concept of a closed community might be gradually eroded by its very success: labour shortages and the ensuing high labour costs are encouraging the employment of outsiders as crewmen who soon are accepted by the local community and often inter-marry across castes:

> "Outsiders by thus becoming insiders provide "sociological bridges" for more outsiders to find entry into what would have once been a closed fishing community which jealously guarded its resources from outsiders. While this brings about an individual gain for the craft-owner ... this is a social cost being incurred at the same time; by breaking the constraint on entry, the community as a whole loses by the setting in motion of a process that will potentially increase the number of competitors on the fishing grounds" (Fernando et. al., 1982.

At this stage, it cannot be predicted whether the Sri Lankan closed community barrier to entry will eventually break under the pressure of labour shortages. As an institution which has exhibited considerable resilience in the past, it might adjust itself to accommodate the new circumstances short of opening the door to the "tragedy of the commons" which has been kept at bay so far 58/.

58/ M. Ben-Yami (pers. comm.) has remarked that "most traditional fishery systems break down not as a result of 'invasions' from outside but because of enterprising 'insiders' who have taken advantage of existing technologies, markets and capital to improve their incomes and who are the first to 'break' the rules and traditions".

Another example of the stark contrast between the situation of a fishery under open access and that of a fishery with traditional fishing rights is provided by the case of two lagoon fisheries in the Ivory Coast (S.M. Garcia, pers. comm.). In Lagoon Ebrie near Abidjan, traditional customary rights of fishermen operating fixed gears broke down following the introduction of mobile gears, such as purse seines, by outsiders (mainly town investors). The Ebrie fishery is now overcapitalized and heavily overexploited in both the biological and economic sense, as evidenced by the small size of fish caught and the relatively low incomes of fishermen. The traditional fishermen are reported to be abandoning the fishery for better employment opportunities in the town, while people with lower opportunity costs from neighbouring countries (Malia and Upper Volta) are entering the fishery to earn a subsistence, thus perpetuating a situation of surplus fishing labour. In contrast, the rather isolated fishery of Lagoon Tagba, over one hundred kilometres from Abidjan, is still controlled by a limited number of chiefs (fishing team leaders) who have knowledge of the biological features of the resource and are enforcing traditional regulations on mesh size and on fishing in spawning areas. Though several tribes operate on the lagoon, the limited migration of catfish, the main species exploited, permits each community to manage its own portion of the lagoon. In the late 1960s, when fishermen from neighbouring countries attempted to introduce purse-seine fishing to the lagoon, a severe conflict arose between them and the local fishermen. The latter managed to capture the purse-seine nets, but they did not use them themselves; they piled them up, instead, as a warning against similar attempts in the future. With so jealously guarded territorial rights, it is no wonder that local fishermen are reported to enjoy relatively high incomes and no surplus labour is evident. Fishermen claim, also, that the size of fish caught has not changed much in living memory.

There are many more examples of traditional customary rights, such as the Brittany seaweed cutting (Troadec, 1982), the Maine lobster fishery (Acheson, 1975; Nagata, 1980) or the Malaysian cockle beds and "pompang" net fishery (Nagata, 1980).

Of course, each of these sytems of traditional customary rights has evolved under the particular circumstances prevailing in certain locations at a given time. Common to most cases was, perhaps, the low population pressure, the subsistence character of the peasant economy and the slow pace of technological progress. It cannot be assumed that these institutions can be preserved intact under the entirely different configuration of population, markets, resources and technology of today. Yet, the revival and rejuvenation of traditional customary systems in the context of the new realities with a limited but crucial government involvement is one of the most promising political options for upgrading and managing artisanal fisheries. As Alexander (1980b:9) put it:

> "The suggestion that customary tenure systems and conservation practices in traditional societies provide the basis for the development of modern coastal management should not be interpreted as an antiquarian's plea for the preservation of a traditional culture. Rather, it is a claim that new institutions, based on the principles embedded in traditional practices, have a critical role in equitable fisheries development. It is a difficult task, but one well worth trying."

V. SUMMARY AND CONCLUSIONS

While small-scale fisheries still employ over 90 percent of all fishermen and contribute about half the edible world catch, they have not received more than scant attention during the past several decades of national and international development. Instead, the emphasis has been on investment promotion for the development of industrial fisheries although this, inevitably, led to over-capitalization and overfishing. It was not altogether irrational at a time when the world fishery resources were open to a competitive race and fossil fuels were relatively inexpensive and capital grossly under-priced.

The new ocean regime, which brought the bulk of the world fishery resources under the control of the coastal states, has raised the possibility of reducing economic waste and using the fishery in the coastal state's best interests. Even developing countries which had not participated in the race for deep-sea fishing find it easier under the new sea regime to plan the development of their national fisheries which have now acquired a definite and exclusive resource base. The escalation of the price of fuel, the high cost of imported capital and the abundance of underemployed labour induced Third World countries to pay more attention to small-scale fisheries which are labour-intensive and use barely any capital or fuel. At the same time, governments are becoming increasingly concerned with socio-economic disparities and are considering assistance measures for small-scale fishermen who are invariably among the lowest income groups.

However, such well-meant efforts might be frustrated without a thorough understanding of the factors responsible for the currently depressed situation of small-scale fisheries and the existing potential for further development. The present study has attempted to put small-scale fisheries in the right perspective by identifying the constraints under which they operate and analysing the effects of alternative interventions in the light of both these constraints and the new opportunities. This has hopefully led to some policy options for improving the socio-economic conditions of small-scale fisheries and maximizing their overall contribution to national economic and social development.

There are a number of aspects of fisheries in general, and small-scale fisheries in particular, which the fisheries administrator needs to consider. A fishery consists of the fishermen, the fleet and the fish stock. The fish stock is a renewable but destructible natural resource, which means that it is capable of some maximum productivity as well as of destruction, depending on man's actions. Through appropriate control of the intensity and pattern of fishing, it is possible to adjust the size, age structure, and species composition of the resource so as to maximize its productivity and, thus, obtain the maximum sustainable catch (MSY). It is important to note that the maximum catch is obtained at less than maximum level of effort. Up to a point, increases in effort bring about almost proportional increases in catch; further increases bring smaller and smaller increases in catch until MSY is reached, beyond which further increases in effort reduce rather than increase catch. Even MSY is too ambitious as a management objective because of the natural and fishing-induced variability of the stocks. Furthermore, since different sizes and species command different prices in the market, the maximum value may not be obtained at maximum catch; it is possible that a smaller sustainable catch consisting of more valuable sizes and species would bring a higher value than a larger catch comprised of mainly trashfish.

Moreover, since it costs money (capital and labour) to catch fish, what matters is neither the volume of the catch nor its (gross) value but the surplus of the value of the catch above the costs of fishing. The maximum surplus or maximum economic yield, (MEY) as it is known, is obtained at a level of fishing effort and catch considerably below the level required for either the maximum sustainable yield or the maximum value of the catch. This is so because expansion of effort beyond a point brings about a less than proportional increase in catch (and value), while costs continue to rise in proportion with effort. The 'optimum' level of effort is reached and further intensification of fishing should be avoided when the last unit of fishing effort added brings in a catch whose value barely covers its costs (including operating costs as well as depreciation and a fair return on capital). The optimum level of effort gives rise to the maximum profit or maximum economic yield which, in a well-functioning, fairly equitable 59/ economy, is equivalent to maximum social benefit. In such an economy, pursuing any other objective such as maximum protein or maximum employment results in a misallocation of the society's scarce resources (capital, human and natural). Clearly, in such an efficient and equitable economy, the objective of fisheries management should be the maximum economic yield or, even better, the maximum present value of the stream of economic yields over the life in the fishery.

59/ Equitable in terms of opportunities not necessarily incomes. An unequal but socially acceptable distribution of income would satisfy this condition.

However, many developing (and quite a few developed) countries do not even remotely approximate the situation of a well-functioning equitable economy. In the presence of severe market failures (monopolies, imperfect capital markets, surplus labour, etc.) and wide socio-economic disparities, employment becomes a consideration, especially in overcrowded small-scale fisheries where "management" requires reduction of effort and hence taking people out of work without other alternatives to offer them. In countries with no effective means of redistributing income, employment in open-access natural resource sectors is for many their last and only means of sharing in the national wealth. To exclude them from the fishery is to deny them their subsistence share. Under conditions of surplus labour, even the exclusion of potential entrants is hard to justify. These considerations seem to suggest maximum fishing employment (and hence maximum fishing effort) as the appropriate objective of fisheries management in the absence of alternative employment opportunities.

However, when one considers the reduction in catch resulting from this overexpansion of effort and the fact that secondary employment (collection, processing and marketing) depends on the volume of the catch, it becomes evident that the fishery generates the maximum overall employment when operated around MSY rather than further to the right at maximum fishing employment. Further, if we add the multiplier-generated employment lost following the dissipation of part of the economic yield, we can conclude that the maximum overall employment is even further to the left, somewhere between MEY and MSY.

Yet, where fishing has become a way of life as well as a source of living, the psychic and social costs of occupational change and relocation might be too high to be ignored in the name of maximizing overall employment. By considering these and other relevant socio-economic issues, we arrive at the concept of maximum social yield (MScY), which may be defined as the best possible rate of exploitation of a fishery under the prevailing socio-economic conditions, where the latter are not taken as parametric but subject to change and control in the long run. Thus, unlike MEY and MSY, MScY does not correspond to a fixed level of effort. In an overcrowded, open-access fishery, MScY would not be far from the prevailing situation to start with, but it would move progressively towards MEY as socio-economic conditions improve (additional resources allocated, alternative employment created and mobility enhanced). When the overall economy operates in an efficient and equitable manner, MScY and MEY would coincide.

In order to asssess the prevailing situation of a given small-scale fishery and design appropriate development and management interventions to attain the MScY, it is necessary to consider first the constraints under which it is operating. Although each to a different degree, small-scale fisheries face a variety of constraints; small, scattered and fluid fishing units, remote and isolated locations, limited open-access resources, multigear technology, multispecies catch, conflicts with large-scale fisheries, limited mobility, and lack of alternative employment opportunities. The open-access status of coastal resources accounts for the oddity (common in fisheries worldwide) that neither the fishermen nor the society at large derive a net value from a valuable resource. It is rare to find fishermen in truly open-access fisheries earning incomes above their opportunity costs (i.e., what they can earn in alternative employment). If some do, it would not be for long; excess profit would attract additional entrants who would compete them away. Traditional barriers to entry, such as customary property rights, have broken-down under the population pressure, the introduction of more efficient technologies by outsiders and the generalization of open-access. Highly specialized skills and lack of alternative employment accounts for small-scale fishermen's low opportunity costs and, hence, for their low incomes. Limited geographical and occupational mobility (itself the result of a host of socio-cultural factors) accounts for the frequent encounter of artisanal fishermen earning incomes even below their opportunity costs. Government efforts to manage and upgrade artisanal fisheries are constrainted by the remoteness, dispersion and fluidity of fishing units, the heterogeneity of the technology used and the multiplicity of the species exploited.

In the light of these constraints and the government's budgetary and administrative limitations, government interventions should be confined to improving and controlling the environment and conditions in which small-scale fisheries operate rather than intervening directly in the fishing operations. It would be far easier, more effective and less costly to allocate more fishery resources to coastal fishermen, to improve infrastructure (including marketing) and to encourage self-regulation than it is to subsidize the motorization of canoes and the use of fuel or to attempt controlling effort through catch quotas. It is also important to recognize that even well-meant interventions may damage rather than benefit those whom they are to assist. For example, a price-support policy or an input subsidy under conditions of open acccess may benefit existing fishermen in the short run but it would certainly damage them in the long term, especially if entry into the fishery is easier than exit.

In general, development without management is likely to be self-defeating even if the resource potential is available, since development creates profits which attract entry until their complete dissipation. On the other hand, management of overexploited fisheries is not enforceable without development of alternative employment opportunities to absorb the surplus labour.

These considerations lead to a strategy for upgrading small-scale fisheries which consists of three inseparable and indispensable components: (a) resource allocation and encouragement of self-management; (b) development of the appropriate environment for a full and equitable utilization of the fishery potential; and (c) development of alternative/supplementary employment opportunities. It is in this context that traditional customary rights may be revived and rejuvenated and used as a tool of fishery management. Traditional community management systems were overrun by population and technological pressures which changed the resource-population balance in an environment depleted of alternatives.

Given the new realities of high population densities and advanced fishing technologies, it is not possible to revive and maintain traditional systems of self-management without some government intervention to provide a conducive environment. Detailed regulation of the activities of thousands of scattered small-scale fishermen is neither required nor enforceable. Similarly, "forced" motorization or input subsidies are not necessary. Once a community has been given exclusive right over a certain fishing ground, and any market distortions and inequalities which prohibit the efficient functioning of the market have been removed or mitigated, motorization would take place only if it serves the purpose of the community. Creation of employment opportunities outside the fishery will serve three purposes: (a) absorb surplus labour, (b) promote mobility, and (c) provide a supplementary/alternative source of living and hence security against uncertainty arising either from market or resource fluctuations. This last point is particularly important since traditional self-management systems tend to break down when lack of alternatives shortens the planning horizon and encourages exploitative behavior for immediate survival.

At this general level of investigation, it is not possible to be more specific without undue generalizations. What specific forms, management schemes and development programmes should take would depend on the specific case under study; their content and form should be sensitive to the context and the available alternatives, but their selection should follow the general principles we have discussed.

In order to establish the context of a small-scale fishery and identify the available alternatives, it is necessary to collect and analyze a minimum amount of data on the biological, economic and social aspects of the fishery as well as its past and present institutional framework (customary rights, open access, etc.). The necessary biological data include the volume, age structure and species composition of the catch and their response to changes in the intensity and the pattern of fishing. The required economic data include price information by species and size, and the cost, composition and distribution of fishing effort (number and size of vessels, number and type of gear, number of fishermen, and fishing time and respective opportunity costs). Information on social aspects should cover mobility, income distribution, availability of non-fishing opportunities for work, related values and motivations and participation in community activities. Institutional information concerns community organization, access to the fishery (whether open or regulated through traditional rights, caste restrictions, etc.), relationship with other fisheries, organization of production (sharing system) and marketing channels and customary relationships between fishermen and middlemen to determine the competitiveness of the market.

This list is indicative rather than exhaustive of the information that might be needed for development and management of a small-scale fishery. At the minimum, the information collected should enable the fishery administrator to determine the relative incomes and general socio-economic conditions of the fishermen and identify the constraints under which they operate. With a bit more information, it should be possible to obtain a quantitative measure (however crude) of the size of the resource and its reaction to fishing intensity which can be combined with economic information on prices and costs to determine the level of effort yielding the maximum economic yield. The latter could then be modified into a maximum social yield by introducing social considerations as constraints on the reduction or expansion of effort to the economic optimum. Finally, institutional information will help select intervention measures best fitted in the organizational structure and historical experience of the particular community. For example, promotion of development through fishermen's associations and of management through community rights is likely to be more successful in communities with a cohesive social structure and some history of customary rights.

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